Firm as a *de facto* Knowledge Aggregator

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Abstract

The aggregation of human capital, a significant and increasingly important source of economic value, justifies the existence of firms. In a simple model, I show that a firm aggregates stakeholders' specific and complex knowledge by altering their risk-taking incentives. One surprising result is that such knowledge aggregation does not necessarily require direct communication, and thus firm creation bypasses potentially high communication costs. This *de facto* knowledge aggregation effect counteracts the free-rider problem, glues highly mobile human capital together, encourages investment and innovation, and endogenizes firm creation. Embedded in a noisy rational expectations model, I further show that investment decisions in a firm dominate market outcomes.

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What is a proper theory of the firm in the knowledge economy? As Zingales (2000) emphasizes in his call for "search of new foundations" (of corporate finance), existing models are in need of re-examination as traditional asset intensive firms are now being gradually peripheralized by human capital intensive ones.[1] Compared to physical assets, human capital tend to be inalienable, rendering a firm theory based on property rights and asset ownership reallocation (e.g. Grossman and Hart (1986)) less applicable. As firms' production as well as service provision require much more intensive employee-possessed human capital today, monitoring effort exertion becomes difficult.[2] In the extreme case where monitoring becomes so costly, free-riding à la Holmström (1982) casts doubt on whether firms should exist at all in the future. It is natural to ask whether firms are superior to the market in incentivizing human-capital intensive business, and if so, how firms glue human capital together?

My paper is a humble step toward answering these questions. In my theory, a firm is interpreted as a revenue-sharing mechanism, as each stakeholder's compensation is ultimately linked to the performance of the firm, or the joint effort/decision of all stakeholders. For entrepreneurs with imprecise private knowledge of the prospect of a risky project, a revenue-sharing firm mimics the effect of exchanging their imprecise knowledge, so that for each of them the perceived project risk is reduced as if by the wisdom of crowd. Such risk reduction encourages investment, and counteracts each stakeholder's free-riding incentive when her unobservable effort is costly. I further prove that in a competitive market, entrepreneurs are always better-off creating firms than running sole proprietorships, so a firm is an endogenous outcome of market participant's utility maximizing behavior. Because revenue-sharing does not necessarily require actual exchange of private knowledge, it facilitates *de facto* knowledge

[1] Similar arguments are found in recent discussions on industrialized economies "secular stagnation" (Summers (2014)). Berk, Stanton, and Zechner (2010), Berk and Walden (2013), and Zhang (2014), among others, discuss implications of human capital on capital structure, asset pricing, and cash flow volatility, respectively.

[2] For example, it is relatively easy to monitor whether a blue-collar worker is shirking (the assembly line would jam if she does), it is more difficult to verify (to a third party) whether your coauthor on an ambitious theory paper has been shirking or not.

aggregation among firm stakeholders when actual knowledge sharing is costly, if not infeasible.[3] Revenue-sharing is also immune to incentive problems that might distort truthful information communication.

In an idealized Modigliani and Miller (1958) world, the existence of firms is irrelevant. A fundamental question in the theory of the firm thus asks "what is the value of the organization structure of a (multi-stakeholder) firm in addition to an economy with only market forces"? In my theory, the value of a firm comes from *de facto* knowledge aggregation via revenue-sharing. While pure market equilibrium also aggregates dispersed knowledge through equilibrium price, I prove that it is nevertheless dominated by revenue-sharing within a firm.[4] This result gives clear-cut justification to the value of a firm in a market economy.

Over 70 years' academic endeavors have proposed several useful explanations to justify the existence of firms. The neoclassic theory views firms as production technology sets. The seminal work of Coase (1937) interprets firms as means to reduce transaction costs, which is further elaborated in Klein, Crawford, and Alchian (1978), Williamson (1975), Williamson (1979), and Williamson (1985). The principal-agent theory explains intra-firm dynamics with management's fiduciary duty (or lack of it) (e.g. Jensen and Meckling (1979)). The "nexus of contracts" theory views a firm as a central contracting party to subsume a complex of multilateral contracts (e.g. Alchian and Demsetz (1972)). The property rights view espoused by Grossman and Hart (1986) and Hart and Moore (1990) emphasizes a defining feature of the firm being the residual rights of control provided by asset ownership.[5] The market intermediary theory (Spulber (1999)) interprets firms as centralized exchanges to reduce

[3]Private knowledge is a fundamental element in entrepreneurs' 1^{st} stage *differentiation* in Rajan (2012).

[4]The informational role of market prices has been widely studied, see Shin (2010), Titman (2013), and Chen, Goldstein, and Jiang (2007), etc. See Goldstein and Guembel (2008) on how the real effect of market prices can be distorted. It is also the underpinning of the extensive literature on noisy rational expectation equilibria, e.g. Grossman and Stiglitz (1980), Hellwig (1980), Diamond and Verrecchia (1981), and Grinblatt and Ross (1985). See Holmström and Tirole (1993) for an alternative example under a Kyle (1985) framework.

[5]See Rajan and Zingales (1998) for an alternative perspective based on asset "access". See further Hart (1989) and Holmström and Tirole (1989) for reviews on the theory of the firm.

market search costs. Demsetz (1988) emphasizes information cost reduction as a foundation of firms. In terms of the importance of understanding firms, in his AFA presidential address, Rajan (2012) emphasizes the importance of understanding the nature of firms to studying corporate finance in general and entrepreneurship in specific. Zingales (2000) argues that the main areas of corporate finance (financing, governance, and valuation) are deeply rooted in an underlying theory of the firm. While existing literature on theory of the firm usually takes a contracting perspective and focuses on (multiple) agents' incentives, a firm's role in information aggregation has received little attention.[6] My paper aims to add to this gap.

The comparison of a firm with a pure rational expectation market equilibrium in terms of information aggregation leads to another technical contribution of my paper. I prove that when a natural institutional innovation is allowed – that agents can create (revenue-sharing) firms – a noisy rational expectation "equilibrium" à la Hellwig (1980) is no longer an equilibrium at all. In fact, agents always have incentives to share revenue with other agents *ex ante*; furthermore, when they have already done so, they still have incentives to expand existing revenue-sharing alliances. In another words, a market "equilibrium" without firm creation is a constrained equilibrium at best.

The superiority of a firm over rational expectation market equilibrium comes from the firm's capability to reduce non-informative noise. To put in historical context, noisy rational expectation models are traditionally developed to study speculative markets. They are useful for understanding how security prices incorporate market information.[7] However, in a thought-provoking paradox, Grossman (1976) shows that strong-form market efficiency is

[6]Notable exceptions include Bolton and Dewatripont (1994), who analyze how organizations minimize information processing and communicating costs. Several recent studies investigate how information distribution among stakeholders influence firm governance. For example, Dicks and Fulghieri (2014) show how ambiguity aversion generates endogenous disagreement between owners and managers, which in turn determines optimal governance structure.

[7]Studies on how prices incorporate information have also inspired extensive theoretical and empirical discussions on market efficiency. See Fama (1970) for early development and Li (2014) for recent empirical investigations.

inconsistent with rational expectation.[8] Addressing this paradox, Diamond and Verrecchia (1981) and Hellwig (1980) develop the seminal concept of noisy rational expectation equilibrium. In a noisy rational expectation equilibrium, additional noise added to asset quantities prevents price from fully-revealing.[9] The introduction of (revenue-sharing) firms in a large market, however, effectively reduces the perceived quantities noise, so that entrepreneurs are better off in a firm than running sole proprietorships.[10]

Without restrictions on alliances formation, the only stable institutional organization is to have all agents enter into a single revenue-sharing alliance. A large revenue-sharing alliance completely mitigates the effect of quantity noises and all stakeholders invest aggressively as if there is no quantity noise. The Grossman (1976) paradox re-emerges. One way to resolve the re-emerged paradox is to adopt a Bayesian Nash equilibrium à la Kyle (1989), where agents take into account their own impact on the equilibrium price. In a linear equilibrium under a single firm, each stakeholder's optimal decision is to post a linear demand schedule, which has finite coefficients even in a large market. That said, the ubiquity of alliance formation frictions in reality makes an economy with small alliances and large market a relevant case (e.g. entrepreneurial startups), thus the revenue-sharing theory developed specifically for a small firm in a large economy is adequately sufficient for describing many empirical facts.

In addition to justifying the existence of a firm, the revenue-sharing theory also sheds light on *inter*-firm industrial organizations. Various inter-firm decisions like stock-based mergers & acquisitions, joint-ventures, and profit-splitting agreements are effectively revenue-sharing contracts. Besides other benefits documented in the literature, these corporate structures keep firms responsive to new investment opportunities and help them take risky (yet positive

[8] The argument, simply put, is that if price is fully revealing, then agents focus solely on the price and discard their private signals when they make investment decisions. But if nobody responds to their private signals, how could these signals be reflected in prices in the first place? Also see Grossman and Stiglitz (1980) on the impossibility of informationally efficient markets.

[9] See Black (1986) for a comprehensive appraisal of "noises".

[10] The tractability of large market analysis is the backbone of Hellwig (1980) as well as follow-up extensions, say Admati (1985).

NPV) projects. In addition, on the *intra*-firm side, the role of revenue-sharing in promoting innovations attests to the value of stock-based compensations (e.g. employee stock ownership plan, ESOP) beyond the traditional incentive alignment argument for senior managers.

A somewhat under-appreciated perspective is that the importance of the theory of the firm is not confined to the territory of corporate finance. To better appreciate this argument, by the end of the paper I give three examples to briefly illustrate how the intuition behind the revenue-sharing theory works in a wide range of topics in banking, mutual fund families, and market microstructure models with social dynamics.

The rest of the paper is organized as follows. Section 1 sets up a simplified Nash equilibrium analysis to illustrate how firm creation facilitates *de facto* knowledge aggregation and counteracts free-riding. Section 2 investigates a rational expectation model to show how firm creation encourages investment. Section 3 proves that creating firms is preferred to running proprietary enterprises. Section 4 formally proves that revenue-sharing is an incentive compatible mechanism to implement truth-telling. Section 5 and 6 briefly discuss further extensions of the revenue-sharing theory to potential applications in mergers & acquisitions, stock-based compensation plans, and topics beyond corporate finance studies. Section 7 concludes. Proofs not in the text are left to the appendices. For completeness Appendix D illustrates the re-emergence of the Grossman (1976) paradox in a single large revenue-sharing alliance, proposes a BNE solution à la Kyle (1989), and caveats its limitations.

1 Firm Creation Facilitates *de facto* Communication

In this section I develop a simple Nash equilibrium model to illustrate the intuition of my theory. The setup is highly stylized and the result might look trivial (with hindsight), but it suffices to convey one of my main results, that revenue-sharing facilitates *de facto* knowledge aggregation. This insight also extends to a general equilibrium model with rational expectation which is reserved for Section 2.

There are two periods and no discounting. A firm is defined by its charter, which specifies a compensation scheme among its n stakeholders. In the simplest case all stakeholders are symmetric, so that upon firm creation in period $t = 0$, the firm charter stipulates that a given stakeholder j will be compensated $\frac{1}{n}$ of the firm's retained earnings by the end of period $t = 1$.[11] Each stakeholder has CARA utility with risk aversion parameter ρ. The firm has a linear production technology $Y = AL$, where Y is total retained earnings, $A \sim \mathcal{N}(\bar{A}, \tau_A^{-1})$ is a stochastic total-factor productivity (TFP), and L is total labor input.[12] I assume that labor input is additive, so that $L = \sum_{j=1}^{n} l_j$, where l_j is the labor input contributed by stakeholder j to the firm. By assuming a linear, additive production technology, I shutdown any complementarity in stakeholders' labors which would mechanically favor firm creation.[13] Each stakeholder's human capital is modeled as her private knowledge in assessing the stochastic TFP. Such private knowledge takes form as sum of the true TFP plus idiosyncratic noise, i.e., stakeholder j's private knowledge $i_j = A + e_j$, where $A \perp\!\!\!\perp e_j$ and $e_j \sim \mathcal{N}(0, \tau_e^{-1})$. In light of both theoretical prediction for (e.g. Rajan and Zingales (2001)) and empirical evidence on (e.g. Rajan and Wulf (2006)) human-capital intensive firms, I assume a flat rather than pyramid governance structure, in which each stakeholder decides on how much effort to put into the project without direct instructions from her colleagues.

In a firm with n stakeholders, entrepreneur j chooses l_j to maximize

$$\mathbb{E}\left[-\exp\left(-\rho\left[\frac{1}{n}A(l_j + \sum_{k\neq j} l_k)\right]\right)|i_j\right], \tag{1}$$

[11]Notice that when all stakeholders are ex ante symmetric, an equal-split charter is the optimal contract. I will further comment on the assumption of symmetry among entrepreneurs in Section 2. If stakeholders are financially constrained, their equity ownership specified in the firm charter could well be "sweat equities".

[12]I interpret Y as retained earnings rather than output for simplicity. Readers loyal to typical production models in the literature can reinterpret A as labor-factor productivity rather than total-factor productivity.

[13]For different modeling purposes, existing literature usually assumes non-separable production technologies, e.g. Alchian and Demsetz (1972). In these models agents' labor input choices impose (usually positive) externalities on each other. Such externalities can either come from output (e.g. Kandel and Lazear (1992)) or cost (e.g. Edmans, Goldstein, and Zhu (2011)).

given her perception of other stakeholders' equilibrium labor input l_k, $k \neq j$. The following theorem provides a linear Nash equilibrium solution for a given stakeholder.

Theorem 1.1. *Given stakeholder j's problem (3), her equilibrium labor input is given by*

$$l_j = \frac{\tau_A \bar{A}}{\rho} + \frac{n\tau_e}{\rho} i_j, \tag{2}$$

Proof. A linear symmetric equilibrium is given by $l_k = \pi + \gamma i_k$ for some π and γ. Because

$$\begin{bmatrix} -\frac{1}{n}\rho A \\ l_j + \sum_{k\neq j} l_k \end{bmatrix}_{|i_j} \sim$$

$$\mathcal{N}\left(\begin{bmatrix} -\rho\frac{1}{n}\mathbb{E}(A|i_j) \\ l_j + (n-1)\pi + (n-1)\gamma\mathbb{E}(A|i_j) \end{bmatrix}, \begin{bmatrix} \rho^2\frac{1}{n^2}\mathrm{Var}(A|i_j) & -\rho\frac{1}{n}(n-1)\gamma\mathrm{Var}(A|i_j) \\ -\rho\frac{1}{n}(n-1)\gamma\mathrm{Var}(A|i_j) & (n-1)^2\gamma^2\mathrm{Var}(A|i_j) + (n-1)\gamma^2\tau_e^{-1} \end{bmatrix}\right)$$

by Lemma A.1 in Appendix A, entrepreneur j equivalently minimizes

$$\begin{aligned} &\theta_2^2\rho^2\frac{1}{n^2}\mathrm{Var}(A|i_j) + 2\theta_1\theta_2\rho\frac{1}{n}(n-1)\gamma\mathrm{Var}(A|i_j) + \theta_1^2[(n-1)^2\gamma^2\mathrm{Var}(A|i_j) + (n-1)\gamma^2\tau_e^{-1}] + 2\theta_1\theta_2 \\ \xrightarrow{\text{FOC}}\ &2\theta_2\rho^2\frac{1}{n^2}\mathrm{Var}(A|i_j) + 2\theta_1\rho\frac{1}{n}(n-1)\gamma\mathrm{Var}(A|i_j) + 2\theta_1 = 0, \\ &\text{where } \theta_1 = -\rho\frac{1}{n}\mathbb{E}(A|i_j) \text{ and } \theta_2 = l_j + (n-1)\pi + (n-1)\gamma\mathbb{E}(A|i_j). \end{aligned}$$

Plugging in $l_j = \pi + \gamma i_j$ leads to

$$[n\pi + \gamma i_j + (n-1)\gamma\mathbb{E}(A|i_j)]\rho\frac{1}{n}\mathrm{Var}(A|i_j) - \rho\frac{1}{n}\mathbb{E}(A|i_j)(n-1)\gamma\mathrm{Var}(A|i_j) - \mathbb{E}(A|i_j) = 0,$$

and matching coefficients renders $l_j = \frac{\tau_A\bar{A}}{\rho} + \frac{n\tau_e}{\rho}i_j$. □

Given no complementarities in labor inputs, one may be tempted to think that entrepreneurs should be indifferent between running a sole proprietorship or participating as a firm stakeholder, nor would firm creation affect real allocation. However, Theorem 1.1 shows that a stakeholder works harder in a firm whenever she has positive assessment of the project prospect (l_j increases with n when $i_j > 0$). Because a stakeholder's assessment are more likely to be positive for a high-value (A) project, creating a firm (rather than keeping multiple sole proprietorships) helps a good project to receive (probablisticly) higher total labor input. Firm creation improves labor allocation.

This result stems from the fact that a firm is a *de facto* information aggregation mechanism. This is summarized in the following theorem.

Theorem 1.2. *Given her private project assessment, an entrepreneur's expected utilities of participating in an n-stakeholder firm is identical to as if she could obtain other $n-1$ entrepreneurs' private knowledge without cost and run a sole proprietorship.*

I will prove a stronger result in Theorem 4.2. One direct implication of this result is that firm creation raises entrepreneurs' expected utilities, and thus is a voluntary outcome of economic evolution. A rough intuition of this *de facto* information aggregation effect comes from the fact that firm creation changes its stakeholders' risk taking incentives. In a CARA-normal setting, each stakeholder's labor input decision is given by a mean-variance trading-off. When in a firm, part of stakeholder j's compensation comes from $\frac{1}{n}$ of the expected value of her labor contribution which only bears $\frac{1}{n^2}$ of its variance. Her labor input is thus more responsive to her knowledge because revenue-sharing in a firm puts her in front of a (as if) less risky project. This effect is reminiscent of what has become conventional wisdom since Markowitz (1952), Sharpe (1964), and Lintner (1965) that proper diversification achieves optimal return-risk trade-off. Firm creation could thus be alternatively interpreted as a mechanism for human-capital diversification.

However, the *de facto* information aggregation channel is different from traditional diversification arguments. First, diversification as in portfolio theory relies on pooling multiple assets and forming portfolios, yet in a revenue-sharing firm model only one single investment project is needed, and the the *de facto* information aggregation is achieved through teaming agents. Second, portfolio theory diversification does not require asymmetric information, yet the *de facto* information aggregation channel is built on stakeholders having dispersed private information. In fact, if there is no private knowledge (i.e., $\tau_e = 0$), revenue-sharing would make no difference.

Remark on *de facto* information aggregation The fact that firm creation mimics the effect of information aggregation without actual communication is important for three reasons. First, knowledge communication in a human capital intensive industry is likely to be costly, if not impossible. For example, stakeholders private assessment of investment project prospect could be based on extensive but haphazard technological know-how, business acumen sharpened over decades of hands-on experience, or several years of intensive training (e.g. doing a Ph.D). These assessments are likely to be impossible to summarize, hard to convey, or takes time to communicate.[14] With revenue-sharing, a firm obtains the same utility outcome bypassing difficult/costly communications.

Second, arms-length direct communication might be incentive-incompatible. Because the *ex post* realizations of private signals are valuable, truth-telling cannot be taken for granted. Furthermore, because the revelation of the realization of v at time $t = 1$ only provides a noisy verification for $t = 0$ signals, even a repeated framework where alliance members can adopt punishment mechanisms for dishonest information sharing would be costly, if not impossible.[15] A revenue-sharing firm resolves this incentive-compatibility concern as the decision to create a firm is *ex ante* and does not involve realizations of signals.

Third, direct communication might face another incentive-compatibility problem: once an entrepreneur receives another entrepreneur's knowledge, she no long has incentive to

[14] Bolton and Dewatripont (1994) explicitly model communication frictions in a theory of the firm.
[15] On repeated games with imperfect monitoring, see Mailath and Samuelson (2006).

honor her promise to reciprocate her valuable knowledge. A revenue-sharing firm is immune to this problem.[16]

Remarks on costly effort One may wonder how the revenue-sharing theory of the firm reconcile with traditional free-riding arguments in existing multi-agent contract theory. The free-riding problem does not arise in the above derivations because *direct* labor cost is not explicitly modeled. When labor cost is included, the decision to form a firm becomes a trade-off between the benefit from *de facto* knowledge aggregation and exacerbated free-riding problem. In human capital intensive industries where individual monitoring cost is high, this trade-off determines optimal firm size and delineates firm boundary. For a specific example, I denote c as the unit labor cost, and each stakeholder chooses her labor input level in a trade-off between (probablisticly) higher $t = 1$ compensation and costly $t = 0$ labor cost.

In a firm with n stakeholders where unit labor cost is c, entrepreneur j chooses l_j to maximize

$$\mathbb{E}\left[-\exp\left(-\rho\left[\frac{1}{n}A(l_j+\sum_{k\neq j}l_k)-cl_j\right]\right)|i_j\right], \tag{3}$$

given her perception of other stakeholders' equilibrium labor input level l_k, $k \neq j$. Using similar solution technique, the stakeholder j's equilibrium labor input is given by

$$l_j = \frac{\tau_A\bar{A}}{\rho} - \frac{1}{\rho}nc\left(\tau_A + n\tau_e\right) + \frac{n\tau_e}{\rho}i_j \tag{4}$$

The equilibrium labor input level is composed of three parts. The first part $\frac{\tau_A\bar{A}}{\rho}$ is a constant, the second part $-\frac{1}{\rho}nc\left(\tau_A + n\tau_e\right)$ is a free-riding effect, and the third part $\frac{n\tau_e}{\rho}i_j$ is an labor-enhancing effect from *de facto* information aggregation. In traditional industries, where

[16]See Dewatripont and Tirole (2005) for further discussions on potential costs and biases in knowledge transfers.

production features *relatively* lower human capital, c is *relatively* high and the free-riding discount dominates. In nascent industries, where production features *relatively* higher human capital, c is *relatively* low and the *de facto* information aggregation premium dominates. In both cases revenue-sharing within a firm, to various extent, incentivizes labor supply and mitigates the free-rider problem.[17]

2 Firm vs Market: Investment Encouragement

This section extends previous analyses to a general equilibrium model and demonstrate how firm creation encourages investment (compared to a pure market economy). To describe the market, I adopt a noisy rational expectation equilibrium setup. The setup is very similar to the one in Section 1, except that I introduce a market valuation of the project which carries both allocative and informational roles.

There is a continuum of entrepreneurs with CARA utility of risk aversion ρ and wealth w. Similar to in Section 1, a firm of size n is defined by its charter which specifies *ex ante* that n entrepreneurs equally receive $\frac{1}{n}$ of any *ex post* realized investment payoff. From time to time, new investment opportunities arrive. Without loss of generality, consider a two-period model with no discounting. On $t = 0$, a risky investment project in need of minimum financing of I arises. The entrepreneurs decide on x, the optimal number of shares to invest in the project. The investment project has *ex ante* valuation of $v \sim \mathcal{N}(\bar{v}, \tau_v^{-1})$ that is determined by nature on $t = 0$ but is not known to anyone until $t = 1$. When making her investment decision, each entrepreneur j is endowed with a signal of the project valuation $i_j = v + e_j$, where v and e_j are independent and $e_j \sim \mathcal{N}(0, \tau_e^{-1})$. The private signal is interpreted as the entrepreneur's private information or expertise/knowledge (in assessing the prospect of

[17] In addition to cost in labor input, free-riding problems could arise through cost in *ex ante* human capital acquisition. The implication out of such setup is similar to the case with labor cost, and the technical details are omitted.

the new investment opportunity). In addition, there is *per-capita* random internal finance z in the market, where $z \sim \mathcal{N}(\bar{z}, \sigma_z^2)$ and carries no information about the project valuation (i.e., $z \perp\!\!\!\perp v$). Notice that if firm creation is not allowd, the above setup is mathematically equivalent to a specific case of Hellwig (1980) with *ex ante* identical entrepreneurs.

Because entrepreneurs are symmetric in terms of their signal precision, the revenue-sharing agreement is an *ex ante* fair deal to all alliance members. The revenue-sharing mechanism captures the reality that each entrepreneur's compensation is based on proportional ownership (in this case equal ownership) in the firm, which is often determined before new investment opportunity emerges.

The $\frac{1}{n}$ revenue-sharing rule is a natural outcome of the symmetric assumption among entrepreneurs. Although solving a more general asymmetric case is technically feasible, it adds much to the complexity of the solution but little to the main idea. In addition to ease of exposition, I focus on the symmetric case here to shut down other benefits of splitting revenues. As Ross (2005) points out, in a Hellwig (1980) economy with agents of heterogeneous signal precision, it is Pareto improving for better-informed agents to charge fees and manage delegated wealth for less informed agents. When the fee takes a proportional form, it is a *de facto* revenue-sharing agreement.[18] A symmetric setting enables us to focus on the risk-reduction effect without considering the information "selling" channel.

Similar to in Section 1, under asymmetric information a firm changes its stakeholders' risk perception. Each firm stakeholder gets $\frac{1}{n}$ of the payoff from the part of the project she invests in, but only $\frac{1}{n^2}$ of the variance. The next two sections show that results parallel to those in the earlier model carry over in a rational expectation setting: that firm creation is utility improving and thus a voluntary behavior out of entrepreneurs' utility-maximization incentives, even though entrepreneurs can already infer others' information from the market price, and the benefit of firm creation comes from *de facto* information aggregation.

[18] See García and Vanden (2009) for wealth delegation with endogenous information acquisition.

3 A Firm is Preferred to A Proprietary Enterprise

I first present a general result on the optimal investment demand and expected utility for an entrepreneur in a size-n firm given an arbitrary linear valuation (price) system. Specific examples then follow to highlight the intuition behind the general result.

Theorem 3.1. *In an economy in which equilibrium project valuation follows a linear function $p = \mu + \pi v - \gamma z$, the optimal investment demand of an entrepreneur j in a firm of size n is given by*

$$x_j = \frac{1}{\rho}[\tau_v \bar{v} - \frac{\pi}{\gamma^2 \sigma_z^2}(\mu - \gamma \bar{z}) + n\tau_e i_j - (n\tau_e + \tau_v + \frac{\pi^2}{\gamma^2 \sigma_z^2} - \frac{\pi}{\gamma^2 \sigma_z^2})p] \tag{5}$$

and her expected utility

$$-\frac{\exp(\frac{A}{2B})}{\sqrt{B}}, \text{ where} \tag{6}$$

$$\begin{aligned} A &= -[\tau_v \bar{v} - \frac{\pi}{\gamma^2 \sigma_z^2}(\mu - \gamma \bar{z}) + \tau_e i_j - (\tau_e + \tau_v + \frac{\pi^2}{\gamma^2 \sigma_z^2} - \frac{\pi}{\gamma^2 \sigma_z^2})p]^2 \frac{n\tau_e + \frac{\pi^2}{\gamma^2 \sigma_z^2} + \tau_v}{(\tau_e + \frac{\pi^2}{\gamma^2 \sigma_z^2} + \tau_v)^2} \\ B &= \frac{n\tau_e + \frac{\pi^2}{\gamma^2 \sigma_z^2} + \tau_v}{\tau_e + \frac{\pi^2}{\gamma^2 \sigma_z^2} + \tau_v} \end{aligned}$$

Proof. See Appendix. □

Theorem 3.1 leads to the following key result.

Theorem 3.2. *The expected utility given by (6) is strictly increasing in the firm size n.*

Proof. Taking derivative of (6) w.r.t n leads to

$$= -\frac{\exp(\frac{A}{2B})}{2B^{\frac{5}{2}}}[A'B - AB' - B], \tag{7}$$

while some algebra would show that $A'B - AB' - B =$

$$-\left\{[\tau_v \bar{v} - \frac{\pi}{\gamma^2 \sigma_z^2}(\mu - \gamma \bar{z}) + \tau_e i_j - (\tau_e + \tau_v + \frac{\pi^2}{\gamma^2 \sigma_z^2} - \frac{\pi}{\gamma^2 \sigma_z^2})p]\mathrm{Var}(v|i_j, p) - (\mathbb{E}(v|i_j, p) - p)\right\}^2 \tau_e -$$

$(n-1)\tau_e \text{Var}(v|i_j, p) - 1 < 0.$ □

Theorem 3.2 shows that for a given linear valuation system, an entrepreneur always finds it optimal to create a firm with other entrepreneurs. Further, entrepreneurs already in a firm also find it optimal to enlarge the existing firm. I discuss two special cases below, in which I highlight several important implications of the result.

3.1 Firm Creation Encourages Investment

In the first special case, I compare the pure market outcome, i.e. an economy with a continuum of entrepreneurs running proprietary enterprises who make independent investment decisions based on both private signals and information inferred from the equilibrium valuation, and the market outcome with the presence of a firm of size n. Because the n entrepreneurs who create a revenue-sharing firm among themselves are of measure zero, and as will be shown, their total investment is one order smaller than the aggregate investment in the market, equilibrium valuation is unchanged from that in an economy with only proprietary enterprises. Thus (see Hellwig (1980)):

$$\tilde{p} = \mu + \pi\tilde{v} - \gamma\tilde{z} \tag{8}$$

$$\mu = \frac{\bar{v}\sigma_z^2 - \tau_v^{-1}\bar{z}\frac{\tau_e}{\rho}}{\sigma_z^2 + \tau_v^{-1}\tau_e\sigma_z^2 + \tau_v^{-1}(\frac{\tau_e}{\rho})^2} \tag{9}$$

$$\pi = \frac{\tau_v^{-1}\tau_e}{\sigma_z^2 + \tau_v^{-1}\tau_e\sigma_z^2 + \tau_v^{-1}(\frac{\tau_e}{\rho})^2}[\sigma_z^2 + \frac{\tau_e}{\rho^2}] \tag{10}$$

$$\gamma = -\frac{\rho\tau_v^{-1}}{\sigma_z^2 + \tau_v^{-1}\tau_e\sigma_z^2 + \tau_v^{-1}(\frac{\tau_e}{\rho})^2}[\sigma_z^2 + \frac{\tau_e}{\rho^2}] \tag{11}$$

Plug in Theorem 3.1, we have,

Corollary 3.3. *In a benchmark economy where all but n entrepreneurs invest as proprietary enterprises, and n entrepreneurs create a revenue-sharing firm, the equilibrium investment* *of a firm member j is given by*

$$x_j = \frac{1}{\rho}[\rho\frac{\rho\sigma_z^2\tau_v\bar{v} - \tau_e\bar{z}}{\rho^2\sigma_z^2 + \tau_e} + n\tau_e i_j - (n\tau_e + \frac{\rho^2\sigma_z^2\tau_v}{\rho^2\sigma_z^2 + \tau_e})p]. \tag{12}$$

In comparison, the investment of entrepreneur j if she is stand-alone is given by

$$\frac{1}{\rho}[\rho\frac{\rho\sigma_z^2\tau_v\bar{v} - \tau_e\bar{z}}{\rho^2\sigma_z^2 + \tau_e} + \tau_e i_j - (\tau_e + \frac{\rho^2\sigma_z^2\tau_v}{\rho^2\sigma_z^2 + \tau_e})p]. \tag{13}$$

The difference between the investment amount of a firm stakeholder and a stand-alone entrepreneur is that the demand of a size-n firm stakeholder has an additional factor of n in front of $\tau_e(i_j - p)$. This means that when in a firm, entrepreneurs become more responsive to the difference between her own signal and the (rationally) expected project valuation. When n is large, this amplification effect dominates, as if the entrepreneur becomes more risk tolerant or as if the noisy existing (non-informational) investment diminishes.

As a side result, I compare the expected utility of a firm stakeholder with that of a stand-alone entrepreneur.

Corollary 3.4. *In an economy where all but n entrepreneurs run proprietary enterprises and invest independently, the expected payoff of an alliance member j is given by*

$$-\frac{\exp(\frac{A}{2B})}{\sqrt{B}}, \text{ where} \tag{14}$$

$$\begin{aligned} A &= -[\tau_v\bar{v} + \frac{\tau_e}{\rho\sigma_z^2}(\frac{\mu}{\gamma} - \bar{z}) + \tau_e i_j - (\tau_e + \frac{\rho^2\sigma_z^2\tau_v}{\rho^2\sigma_z^2 + \tau_e})p]^2 \frac{n\tau_e + \frac{\tau_e^2}{\rho^2\sigma_z^2} + \tau_v}{(\tau_e + \frac{\tau_e^2}{\rho^2\sigma_z^2} + \tau_v)^2} \\ B &= \frac{n\tau_e + \frac{\tau_e^2}{\rho^2\sigma_z^2} + \tau_v}{\tau_e + \frac{\tau_e^2}{\rho^2\sigma_z^2} + \tau_v} \end{aligned}$$

When $n = 1$, by standard moment generating function of a normal variable, we have that the expected payoff of an entrepreneur is given by

$$-\exp\Big\{-\Big[\tau_v\bar{v}+\tfrac{\tau_e}{\rho\sigma_z^2}(\tfrac{\mu}{\gamma}-\bar{z})+\tau_e i_j-(\tau_e+\tfrac{\rho^2\sigma_z^2\tau_v}{\rho^2\sigma_z^2+\tau_e})p\Big]\left[\mathbb{E}(v|i_j,p)-p\right]+ \frac{1}{2}\Big[\tau_v\bar{v}+\tfrac{\tau_e}{\rho\sigma_z^2}(\tfrac{\mu}{\gamma}-\bar{z})+\tau_e i_j-(\tau_e+\tfrac{\rho^2\sigma_z^2\tau_v}{\rho^2\sigma_z^2+\tau_e})p\Big]^2 \mathrm{Var}(v|i_j,p)\Big\}, \tag{15}$$

where $\mathbb{E}(v|i_j,p)=\frac{\tau_v\bar{v}+\frac{\tau_e}{\rho\sigma_z^2}(\frac{\mu}{\gamma}-\bar{z})+\tau_e i_j-(\tau_e+\frac{\rho^2\sigma_z^2\tau_v}{\rho^2\sigma_z^2+\tau_e})p}{\tau_e+\frac{\tau_e^2}{\rho^2\sigma_z^2}+\tau_v}$, and $\mathrm{Var}(v|i_j,p)=\frac{1}{\tau_e+\frac{\tau_e^2}{\rho^2\sigma_z^2}+\tau_v}$. Not surprisingly, we see that (15) coincides with (14) when $n=1$.

3.2 Extension to Multiple Firms

Section 3.1 shows that having all entrepreneurs committed to proprietary enterprises is not an equilibrium because any set of entrepreneurs always have incentives to unilaterally create a revenue-sharing firm. Given the symmetric setup, it is natural to investigate the price efficiency, trading behavior, and welfare impact when *all* entrepreneurs in the continuum create their own revenue-sharing firms (of size n). The major difference from Section 3.1 is that when *all* entrepreneurs (rather than a measure zero of entrepreneurs) invest more aggressively due to the extra risk-taking incentives brought by firms, the equilibrium price changes. However, in a symmetric, linear rational expectation equilibrium, I show that the main idea in Section 3 carries through without change, namely 1) entrepreneurs become more responsive to the difference of their own signal and the (rationally) expected project valuation; 2) entrepreneurs have the incentive to unilaterally further expand existing firms. These intuitions are formally summarized in the corollary below.

Corollary 3.5. *When all entrepreneurs are in their respective firms of size n, the equilibrium* *project valuation is given by*

$$\begin{cases} p &= \mu + \pi v - \gamma z \\ \mu &= \frac{\sigma_z^2\rho^2}{(n\tau_e+\tau_v)\sigma_z^2\rho^2+n^2\tau_e^2}(\tau_v\bar{v} - \frac{n\tau_e}{\rho\sigma_z^2}\bar{z}) \\ \pi &= -\frac{n\tau_e}{\rho}\gamma = \frac{n\tau_e(n\tau_e+\sigma_z^2\rho^2)}{(n\tau_e+\tau_v)\sigma_z^2\rho^2+n^2\tau_e^2} \\ \gamma &= -\frac{n\tau_e\rho+\sigma_z^2\rho^3}{(n\tau_e+\tau_v)\sigma_z^2\rho^2+n^2\tau_e^2} \end{cases} . \tag{16}$$

The equilibrium demand of entrepreneur j is given by

$$\frac{1}{\rho}[\tau_v\bar{v} - n\tau_e(\frac{\tau_v\bar{v}+\rho\bar{z}}{n\tau_e+\sigma_z^2\rho^2}) + n\tau_e i_j - (n\tau_e + \frac{\rho^2\sigma_z^2\tau_v}{\rho^2\sigma_z^2+n\tau_e})p]. \tag{17}$$

Proof. Appendix. □

Equation (17) shows that when all entrepreneurs create their respective size-n firms, two forces change each entrepreneur's investment decision. The first force is a direct effect of increased *effective* risk tolerance similar to that in equation (12), generated from entrepreneur j's firm creation decision. The second one is due to changes in the equilibrium project valuation, generated from *all* entrepreneurs' decisions to create firms. As along as one single entrepreneur's unilateral firm creation does not impact market wide equilibrium project valuation (e.g. creating a start-up), her investment is strictly more sensitive to the difference between her private signal and equilibrium project valuation.

The fact that a single entrepreneur always has the incentive to *unilaterally* further enlarge her firm leads to a natural conjecture, that the ultimate market outcome would be one in which an industry-wide monopoly emerges, given that the economy is frictionless in alliance formation. Appendix D investigates this case in detail. However, since in reality the economy is fraught with various frictions, including but not limited to legal restrictions (e.g. anti-trust regulation), search frictions (i.e. it takes time to find another entrepreneurs interested in the same project), or entrepreneur behavioral bias (i.e. entrepreneurs might fail to recognize the revenue-sharing benefit of a firm), it is appropriate to restrict our focus on small alliances (relative to the market), and as Section 5 will discuss in more detail, the case of small alliances already has rich implications for several empirical facts. .

4 Sharing Revenue Versus Sharing Signals

To demonstrate the *de facto* information aggregation effect under a rational expectation market setting, this section compares a revenue-sharing firm with a natural counterpart: sharing private signals among entrepreneurs prior to making investment decisions. Formally, a *signal-sharing alliance* is defined as follows: n entrepreneurs at period 0 share exchange signals among themselves, and use the average of all the signals to make investment decisions. Denote $\frac{1}{n}\sum_{k \text{ within alliance}} i_k$ as $i^* = v + e^*$, then $v \perp\!\!\!\perp e^*$ and $e^* \sim \mathcal{N}(0, \frac{1}{n}\tau_e^{-1})$.

Consider an arbitrary linear valuation system in which $p = \mu + \pi v - \gamma z$. The investment by member j in an signal-sharing alliance is given by maximizing

$$\mathbb{E}\left[-\exp(-\rho(v-p)x_j | i^*, p\right], \text{ and thus} \tag{18}$$

$$\Rightarrow x_j = \frac{\mathbb{E}(v|i^*,p)-p}{\rho \mathrm{Var}(v|i^*,p)} = \frac{1}{\rho}[\tau_v \bar{v} - \frac{\pi}{\gamma^2\sigma_z^2}(\mu - \gamma\bar{z}) + n\tau_e i^* - (n\tau_e + \tau_v + \frac{\pi^2}{\gamma^2\sigma_z^2} - \frac{\pi}{\gamma^2\sigma_z^2})p] \tag{19}$$

$$(\text{Notice that } \begin{cases} \mathbb{E}(v|i^*,p) &= \ = \frac{\gamma^2\sigma_z^2\tau_e i^* + \frac{1}{n}\pi(p-\mu+\gamma\bar{z}) + \frac{1}{n}\gamma^2\sigma_z^2\tau_v\bar{v}}{\gamma^2\sigma_z^2\tau_e + \frac{1}{n}\pi^2 + \frac{1}{n}\gamma^2\sigma_z^2\tau_v} \\ \mathrm{Var}(v|i^*,p) &= \ \frac{\frac{1}{n}\gamma^2\sigma_z^2}{\gamma^2\sigma_z^2\tau_e + \frac{1}{n}\pi^2 + \frac{1}{n}\gamma^2\sigma_z^2\tau_v} \end{cases}) \tag{20}$$

Compared to (5), the demand in a revenue-sharing firm differs from the demand in a signal-sharing alliance only in that the former uses the realization of individual signal i_j, while the latter uses the realization of alliance-averaged signal i^*.

Because $\frac{1}{n}\sum_{k \text{ within alliance}} i_k = i^*$, equation (19) immediately shows that the total (*ex post*) investment of all the members in a revenue-sharing firm and a signal-sharing alliance is the same. A direct conclusion from this observation is that equilibrium valuation in both structures are identical. In another word, there is an isomorphism between sharing signals and creating a firm in terms of equilibrium valuation. This result applies to any (potentially asymmetric) structures in the whole economy. As will be shown below, such isomorphism extends to each entrepreneurs' *interim* expected utility (after receiving own private signal but before the alliance-forming or firm-creating decision) as well.

Lemma 4.1. *After receiving her private signal, the expected utility for entrepreneur j to form an signal-sharing alliance of size n is:*

$$-\frac{\exp\left(-\frac{1}{2}\frac{1}{\tau_e+\frac{\pi^2}{\gamma^2\sigma_z^2}+\tau_v}\left[\tau_e i_j-\frac{\pi}{\gamma^2\sigma_z^2}(\mu-\gamma\bar{z})+\tau_v\bar{v}-(\tau_e+\tau_v+\frac{\pi^2}{\gamma^2\sigma_z^2}-\frac{\pi}{\gamma^2\sigma_z^2})p\right]^2\right)}{\sqrt{\frac{n\tau_e+\frac{\pi^2}{\gamma^2\sigma_z^2}+\tau_v}{\tau_e+\frac{\pi^2}{\gamma^2\sigma_z^2}+\tau_v}}} \tag{21}$$

Proof. See Appendix. □

Theorem 4.2. *An entrepreneur's interim expected utilities (after receiving own private signal but before the alliance-forming or firm-creating decision) are identical in a firm and in a signal-sharing alliance.*

Proof. By Theory 3.1, the the expected utility of an entrepreneur j in a firm is

$$-\frac{\exp(\frac{A}{2B})}{\sqrt{B}}, \text{ where} \tag{22}$$

$$\begin{aligned} A &= -[\tau_v\bar{v}-\frac{\pi}{\gamma^2\sigma_z^2}(\mu-\gamma\bar{z})+\tau_e i_j-(\tau_e+\tau_v+\frac{\pi^2}{\gamma^2\sigma_z^2}-\frac{\pi}{\gamma^2\sigma_z^2})p]^2\frac{n\tau_e+\frac{\pi^2}{\gamma^2\sigma_z^2}+\tau_v}{(\tau_e+\frac{\pi^2}{\gamma^2\sigma_z^2}+\tau_v)^2} \\ B &= \frac{n\tau_e+\frac{\pi^2}{\gamma^2\sigma_z^2}+\tau_v}{\tau_e+\frac{\pi^2}{\gamma^2\sigma_z^2}+\tau_v}, \end{aligned}$$

which is exactly the same as the *ex ante* expected utility of an entrepreneur j in an signal-sharing alliance, shown in Lemma 4.1. □

5 Further Extensions and Application

In this section, I leverage the revenue-sharing intuition to shed light on extensions to inter-firm relations and intra-firm compensation arrangement. Section 6 discusses further applications beyond corporate finance. In the spirit of Roll (1986), these applications are less conclusive, and are mentioned in hope of enough plausibility to be considered in further investigations.

5.1 M&A, Joint Ventures, and Profit-Splitting Agreements

With only modest adaption, the revenue-sharing intuition serves as an alternative motivation for mergers and acquisitions.[19] Stock-based deals are essentially contracts between the acquirer and the target to share revenues proportional to post-merger equity ownership. According to the revenue-sharing theory, such deals could improve industry-wide resource allocation through a "*de facto* information aggregation synergy": a newly merged firm expands its investment opportunity set as projects previously deemed too risky under separate firms would be perceived less so post-merger. Admittedly, the revenue-sharing synergy is unlikely to capture the entire picture of merger and acquisition motivations, but it is a likely complement to existing theories.

Existing literature has proposed many theories as motivations for mergers and acquisitions. From a neoclassic view, mergers are triggered by synergy seeking. Mitchell and Mulherin (1996) provide evidence that much of the takeover activity during the 1980s was driven by broad fundamental factors. Harford (2005) finds that economic, regulatory and technological shocks drive industry merger waves. From a market power perspective, Lambrecht (2004) models merger decisions as solutions to a real option problem for firms with

[19] See Rhodes-Kropf and Robinson (2008) for discussions on mergers and acquisitions based on a property rights theory of the firm.

economy of scale technologies.[20] Grossman and Hart (1980) and Grossman and Hart (1988) emphasize the role of corporate takeovers in enforcing market disciplines. From a behavioral perspective, Roll (1986) and Malmendier and Tate (2008) links M&As to management overconfidence. Harford (1999) argues that excessive cash reserves lead to (value-destructing) acquisitions. Shleifer and Vishny (2003) develop a market-timing theory of M&A based on stock market misvaluations of the combining firms and the market's perception of synergies. Rhodes-Kropf, Robinson, and Viswanathan (2005) test and confirm that valuation errors affect merger activity. With an eclectic view, Dong, Hirshleifer, Richardson, and Teoh (2006) evaluate the misvaluation and Q theories of takeovers using pre-offer market valuations and find that the evidence for the Q hypothesis is stronger in the pre–1990 period, whereas the evidence for the misvaluation hypothesis is stronger in the 1990–2000 period.

Joint venture, another commonly observed industry organization, is also essentially a revenue-sharing alliance. In addition, explicit revenue-sharing agreement is also seen in the corporate world. One most cited example is the Royal-Dutch / Shell Group case:

> The Royal-Dutch / Shell Group grew out of a 1907 alliance between Royal Dutch and Shell Transport by which the two companies agreed to merge their interests on a 60/40 basis while remaining separate and distinct entities. All cash flows were divided 60/40 between Royal Dutch and Shell shareholders.[21]

I leave further investigation into the application of revenue-sharing theory in industrial organization to future research.

[20] Also see Morellec and Zhdanov (2005) and Hackbarth and Miao (2007).

[21] This example is probably better known in the behavioral finance literature. Although in theory the market value of Royal Dutch should equal 60/40 times that of Shell, in reality such convergence was a non-exist for decades, see Barberis and Thaler (2003).

5.2 Compensation: ESOPs and Profit-Sharing Plans

As already touched upon before, stock-based compensation could be viewed as a form of revenue-sharing. Stock-based compensation is most common among the senior management of a firm, but it also sometimes involves rank-and-file employees, in the form of profit-sharing plans or employee stock ownership plans (ESOPs).

According to The National Center for Employee Ownership,[22] "in an ESOP, a company sets up a trust fund, into which it contributes new shares of its own stock or cash to buy existing shares. Alternatively, the ESOP can borrow money to buy new or existing shares, with the company making cash contributions to the plan to enable it to repay the loan. Regardless of how the plan acquires stock, company contributions to the trust are tax-deductible, within certain limits."

Existing views on why firms adopt ESOPs include tax benefits, incentive alignment, takeover defense, or creating a sense of ownership among employees.[23] In addition, when ESOPs are viewed as revenue-sharing mechanisms among employees, it helps create a culture of entrepreneurship within the firm (Theorem 3.1). The fact that ESOPs are particular common among R&D intense firms supports this revenue-sharing view. For example, using proprietary data, Ittner, Lambert, and Larcker (2003) provide evidence that "new economy" firms offer more equity grants to employees than "old economy" firms.[24]

[22] `http://www.nceo.org/articles/esop-employee-stock-ownership-plan`.

[23] See Beatty (1995), Core and Guay (2001), Graham, Lang, and Shackelford (2004), etc.

[24] Personal communications also confirm that IT firms, like Google and Microsoft, operate highly developed ESOPs.

6 Extensions beyond Corporate Finance

6.1 Banking: Systemic Risk and "Too-Big-to-Fail" Banks

When the revenue-sharing view for merger & acquisition is applied to the banking industry, it sheds light on inter-bank relations, and the rise of "too-big-to-fail" banks. Various inter-bank structures, like cross-ownership, inter-bank lending as well as mergers are effectively revenue-sharing contracts. These contracts keep banks responsive to the financing need of risky (yet positive NPV) investment projects. Furthermore, according to Theorem 3.2, bank's inclination to enlarge revenue-sharing alliance sizes provides an alternative explanation for the rise of "too-big-to-fail" banks. In reality, mergers and acquisitions are accountable for increased bank sizes, reduced bank numbers, as well as the birth of the four national U.S. banks. According to Erel (2011), "during the 1990s, the number of commercial banks in the United States decreased from about 12,500 to about 8,000, primarily due to a wave of bank mergers that led to an increase in the average size of banks". Figure 1, from the Federal Reserve System illustrates the making of the Big-4 U.S. banks through mergers and acquisitions.

Figure 1 here

A direct outcome from merged banks as well inter-bank relations is the perceived extreme risk taking of banks. While it is *ex ante* optimal for banks to take aggressive positions when organized under *de facto* alliances, such aggressive positions magnify small (unexpected) shocks to economy-wise parameters. To formally see this, consider Equation (17):

$$x_j = \frac{1}{\rho}[\tau_v\bar{v} - n\tau_e(\frac{\tau_v\bar{v} + \rho\bar{z}}{n\tau_e + \sigma_z^2\rho^2}) + n\tau_e i_j - (n\tau_e + \frac{\rho^2\sigma_z^2\tau_v}{\rho^2\sigma_z^2 + n\tau_e})p].$$

When no alliance is formed ($n = 1$), a tiny shock to private signal precision τ_e does not deviate the bank's demand too far from its optimal level. However, when banks enter into alliances of size n, any such deviation is magnified by n. When n gets large, a small shock to the economy exposes banks to largely suboptimal investment decisions. Revenue-sharing amplifies systemic risk.

6.2 Capital Markets: Rise of Mutual Fund Families

Why are so many mutual funds organized in fund families? What is the value-added of such an industrial organization to standalone funds? One compelling argument is that mutual fund families saves redundant marketing expenses, technology costs, and other overheads. Alternatively, Cheng, Massa, Spiegel, and Zhang (2012) argues that "fund families exist in part to allocate talented managers into areas with superior support systems that a standalone operation cannot easily duplicate". Fund family could also be a marketing devise. Gaspar, Massa, and Matos (2006) find "mutual fund families strategically transfer performance across member funds to favor those more likely to increase overall family profits".

Kempf and Ruenzi (2008) find that mutual fund managers adjust the risk they take depending on the relative position within their fund family. Yet, does this result extend so that the mere fact that a fund belongs to a family changes its manager's behavior? From a revenue-sharing perspective, I expect the answer to be yes. Because risk-averse fund managers are better off when they are in a *de facto* revenue-sharing alliance incarnated as a fund family, the popularity of mutual fund families could be a natural outcome of institutional innovations. Because a manager takes more risks when she could (even if only partially) share revenue with other fund managers in the same family, her performance is improved as expected fund return goes higher.

6.3 Market Microstructure: Information Percolation

The fact that sharing revenues is an effective and incentive compatible implementation for sharing private signals (Theorem 4.2) uncovers hidden implications from existing models that involve information dispersion.[25] For example, beginning from Duffie and Manso (2007), in recent years studies on information percolation, which explicitly model the social dynamics of information dispersion, receive wide attention.[26] One fundamental assumption of these models builds on investors' truth telling behavior with respect to their private information. Although this assumption serves a natural benchmark and might sometimes be true in reality, it is nevertheless exogenously specified and awaits further empirically test.[27]

Revenue sharing provides an incentive compatibility alternative. According to Theorem 4.2, revenue-sharing replicates the benefit of information-sharing. Furthermore, because the decision to enter into revenue-sharing alliances is *ex ante* and does not involve disclosure of each investor's signal realization, there are no concerns over incentive-compatibility.

7 Conclusion

My paper proposes a new theory of the firm. Interpreted as revenue-sharing alliances, firms emerge endogenously out of entrepreneur' utility maximization incentives. I show that firms counteract the free-rider problem, encourage innovation, and facilitate *de facto* knowledge aggregation. The creation of a firm dominates market allocation. Furthermore, voluntary

[25] For example, in a signaling game model, Bommel (2003) show how capital-constrained informed investors disseminate their private signals to uninformed investors to increase their trading profit. Models on information cascade (e.g. Welch (1992) and Bikhchandani, Hirshleifer, and Welch (1992)) show how information externality can severely distort asset prices.

[26] See also Duffie, Malamud, and Manso (2009), Duffie, Giroux, and Manso (2010), Andrei and Cujean (2013), and Duffie, Malamud, and Manso (2014).

[27] The large market setup in these models somewhat ameliorates the incentive-compatibility problem because in a large market any single investor does not move the price. That said, even in this case, there is still no incentive to prevent investors from telling lies, and the lying incentive exists naturally as the large market is a limiting case of a finite investors market, in which investors strictly prefer lying.

revenue-sharing among existing firms motivates mergers, joint ventures, and profit-splitting agreements. In addition, within a single firm, launching stock-based compensations like ESOPs encourages innovative activities. This revenue-sharing intuition generally applies to all firms (to heterogeneous extents), but it is particularly relevant for those increasingly important human-capital intensive firms.

The equivalence of revenue-sharing and information sharing has potential implications for optimal board structure. Recent advances in this line of literature emphasize the trade-off between independent directors' better monitoring role and insider directors' more effective advisory role.[28] Based on the revenue-sharing theory, with proper compensation arrangement it may not be necessary to emphasize information transmission, and the optimal board structure should indeed focus on monitoring as it is currently in reality (e.g. the spirit of the Sarbanes-Oxley Act). That said, studies on optimal board structures typically model information differently from the current paper, and I leave their conciliation to future studies.

Outside of corporate finance, the intuition behind the revenue-sharing theory also has implications for the rise of "too-big-to-fail" banks, systemic risk, the role of mutual fund families, and the incentive-compatibility foundation for information percolation models. I highlight the linkage between the theory of the firm and a wide range of other finance fields.

One question left unanswered is the economic significance of this revenue-sharing channel. For an empirical assessment an identification strategy needs to be developed, as the roles of revenue-sharing behind various economic phenomena are simultaneously confounded by other theories already established in the literature. Does the revenue-sharing channel offer additional explanation power? If so, how much? For an empirical exercise to match reality, *ex ante* asymmetry also needs to introduced. Future work should explore this further.

Most of the comparison of firm and market are made in a "small alliance" scenario.

[28]See, for example, Adams and Ferreira (2007), Harris and Raviv (2008), Levit (2012), and Chakraborty and Yilmaz (2010).

Appendix D provides an equilibrium solution to the "large alliance" case, and future research would explore its implication in more detail. Of particular interest is the fact that when the firm is large enough, its stakeholder's investment decisions become hardly sensitive to firm size. This might have implications for how does the number of stakeholders affect firm value, as well as the optimal capital structure (from a stakeholder perspective).

Last but not least, the welfare-equivalence between sharing revenue and sharing information might suggest an often neglected information channel. For example, how effective are Chinese walls between firm subdivisions that are exposed to conflict of interests? Does revenue-sharing camouflage insider trading? These questions might concern regulators, and more thorough thinking is scheduled for future research.

Appendix

A Proof of Theorem 3.1

The following lemma turns out to be useful in later analysis:

Lemma A.1. *If* $\begin{bmatrix} x \\ y \end{bmatrix} \sim \mathcal{N}\left(\begin{bmatrix} \theta_1 \\ \theta_2 \end{bmatrix}, \begin{bmatrix} \sigma_1^2 & \rho\sigma_1\sigma_2 \\ \rho\sigma_1\sigma_2 & \sigma_2^2 \end{bmatrix} \right)$, *where* $(\rho\sigma_1\sigma_2 - 1)^2 > \sigma_1^2\sigma_2^2$ *then*

$$\mathbb{E}\left[e^{xy}\right] = \frac{\exp\left\{(\theta_2^2\sigma_1^2 - 2\rho\theta_1\theta_2\sigma_1\sigma_2 + \theta_1^2\sigma_2^2 + 2\theta_1\theta_2)/(2[(\rho\sigma_1\sigma_2 - 1)^2 - \sigma_1^2\sigma_2^2])\right\}}{\sqrt{(\rho\sigma_1\sigma_2 - 1)^2 - \sigma_1^2\sigma_2^2}}.$$

Proof. Standard integration. □

Proof of Theorem 3.1: Entrepreneur j's investment in the risky project when in a firm is given by maximizing

$$\mathbb{E}\left[-\exp(-\rho(v-p)(x_j+\sum_{k\neq j}x_k)/n)|i_j,p\right] \tag{23}$$

Focusing on symmetric linear equilibria, assume $x_k = n\alpha_0 + n\alpha_1 i_k + n\alpha_2 p$, where α_i $(i = 0, 1, 2)$ are functions of n. Notice that

$$(x_j+\sum_{k\neq j}x_k)/n = x_j/n + (n-1)\alpha_0 + (n-1)\alpha_1 v + (n-1)\alpha_2 p + \alpha_1 \sum_{k\neq j} e_k, \tag{24}$$

thus

$$\begin{pmatrix} -\rho(v-p) \\ (x_j+\sum_{k\neq j}x_k)/n \end{pmatrix}_{|i_j,p} \sim \mathcal{N}\left(\begin{bmatrix} -\rho\mathbb{E}(v|i_j,p)+\rho p \\ x_j/n+(n-1)\alpha_0+(n-1)\alpha_1\mathbb{E}(v|i_j,p)+(n-1)\alpha_2 p \end{bmatrix}, \begin{bmatrix} \rho^2\mathrm{Var}(v|i_j,p) & -\rho(n-1)\alpha_1\mathrm{Var}(v|i_j,p) \\ -\rho(n-1)\alpha_1\mathrm{Var}(v|i_j,p) & (n-1)^2\alpha_1^2\mathrm{Var}(v|i_j,p)+\alpha_1^2(n-1)\tau_e^{-1} \end{bmatrix} \right) \tag{25}$$

By Lemma A.1, the certainty equivalent of (23) is

$$-\frac{\exp(\frac{A}{2B})}{\sqrt{B}}, \tag{26}$$

where

$$\begin{aligned} A &= (-\rho\mathbb{E}(v|i_j,p)+\rho p)^2[(n-1)^2\alpha_1^2\mathrm{Var}(v|i_j,p)+\alpha_1^2(n-1)\tau_e^{-1}] \\ &+ [x_j/n+(n-1)\alpha_0+(n-1)\alpha_1\mathbb{E}(v|i_j,p)+(n-1)\alpha_2 p]^2\rho^2\mathrm{Var}(v|i_j,p) \\ &+ 2(-\rho\mathbb{E}(v|i_j,p)+\rho p)[x_j/n+(n-1)\alpha_0+(n-1)\alpha_1\mathbb{E}(v|i_j,p)+(n-1)\alpha_2 p][1+ \\ & \quad \rho(n-1)\alpha_1\mathrm{Var}(v|i_j,p)] \\ B &= [\rho(n-1)\alpha_1\mathrm{Var}(v|i_j,p)+1]^2 \\ &- \rho^2\mathrm{Var}(v|i_j,p)[(n-1)^2\alpha_1^2\mathrm{Var}(v|i_j,p)+\alpha_1^2(n-1)\tau_e^{-1}] \end{aligned}$$

Taking FOC w.r.t. x_j we get

$$\begin{aligned} & x_j/n+(n-1)\alpha_0+(n-1)\alpha_1\mathbb{E}(v|i_j,p)+(n-1)\alpha_2 p && (27) \\ = & \frac{(-\rho(n-1)\alpha_1\mathrm{Var}(v|i_j,p)-1)(-\rho\mathbb{E}(v|i_j,p)+\rho p)}{\rho^2\mathrm{Var}(v|i_j,p)} && (28) \\ = & \frac{[\rho(n-1)\alpha_1\mathrm{Var}(v|i_j,p)+1](\mathbb{E}(v|i_j,p)-p)}{\rho\mathrm{Var}(v|i_j,p)}. && (29) \end{aligned}$$

Given (8), we have

$$\left\{ \begin{array}{lcl} \mathbb{E}(v|i_j,p) &=& \bar{v}+\frac{\gamma^2\sigma_z^2\tau_v^{-1}(i_j-\bar{v})+\pi\tau_v^{-1}\tau_e^{-1}(p-\mu-\pi\bar{v}+\gamma\bar{z})}{\gamma^2\sigma_z^2\tau_v^{-1}+\pi^2\tau_v^{-1}\tau_e^{-1}+\gamma^2\sigma_z^2\tau_e^{-1}} = \frac{\gamma^2\sigma_z^2\tau_v^{-1}i_j+\pi\tau_v^{-1}\tau_e^{-1}(p-\mu+\gamma\bar{z})+\gamma^2\sigma_z^2\tau_e^{-1}\bar{v}}{\gamma^2\sigma_z^2\tau_v^{-1}+\pi^2\tau_v^{-1}\tau_e^{-1}+\gamma^2\sigma_z^2\tau_e^{-1}} \\ \mathrm{Var}(v|i_j,p) &=& \tau_v^{-1}-\frac{\gamma^2\sigma_z^2\tau_v^{-2}+\pi^2\tau_v^{-2}\tau_e^{-1}}{\gamma^2\sigma_z^2\tau_v^{-1}+\pi^2\tau_v^{-1}\tau_e^{-1}+\gamma^2\sigma_z^2\tau_e^{-1}} = \frac{\gamma^2\sigma_z^2\tau_e^{-1}\tau_v^{-1}}{\gamma^2\sigma_z^2\tau_v^{-1}+\pi^2\tau_v^{-1}\tau_e^{-1}+\gamma^2\sigma_z^2\tau_e^{-1}} \end{array} \right. \quad (30)$$

In equilibrium $x_j = n\alpha_0 + n\alpha_1 i_j + n\alpha_2 p$, and Equation (29) leads to

$$n\alpha_0+\alpha_1 i_j+(n-1)\alpha_1\mathbb{E}(v|i_j,p)+n\alpha_2 p = \frac{[\rho(n-1)\alpha_1\mathrm{Var}(v|i_j,p)+1](\mathbb{E}(v|i_j,p)-p)}{\rho\mathrm{Var}(v|i_j,p)}, \quad (31)$$

thus

$$\rho\mathrm{Var}(v|i_j,p)\,[n\alpha_0+\alpha_1 i_j+n\alpha_2 p] = -\rho(n-1)\alpha_1\mathrm{Var}(v|i_j,p)p+\mathbb{E}(v|i_j,p)-p \quad (32)$$

Plug in (30),

$$\rho\left[n\alpha_0 + \alpha_1 i_j + n\alpha_2 p\right] = -\rho(n-1)\alpha_1 p - \frac{\gamma^2\sigma_z^2\tau_v^{-1} + \pi^2\tau_v^{-1}\tau_e^{-1} + \gamma^2\sigma_z^2\tau_e^{-1}}{\gamma^2\sigma_z^2\tau_e^{-1}\tau_v^{-1}}p + \tag{33}$$

$$\frac{\gamma^2\sigma_z^2\tau_v^{-1}i_j + \pi\tau_v^{-1}\tau_e^{-1}(p-\mu+\gamma\bar{z}) + \gamma^2\sigma_z^2\tau_e^{-1}\bar{v}}{\gamma^2\sigma_z^2\tau_e^{-1}\tau_v^{-1}} \tag{34}$$

Equalizing coefficients:

$$\begin{cases} \rho n\alpha_0 &= \tau_v\bar{v} - \frac{\pi}{\gamma^2\sigma_z^2}(\mu-\gamma\bar{z}) \\ \rho\alpha_1 &= \tau_e \\ \rho n\alpha_2 &= -(n-1)\tau_e - (\tau_e+\tau_v+\frac{\pi^2}{\gamma^2\sigma_z^2}) + \frac{\pi}{\gamma^2\sigma_z^2} \end{cases} \tag{35}$$

Thus

$$x_j = \frac{1}{\rho}[\tau_v\bar{v} - \frac{\pi}{\gamma^2\sigma_z^2}(\mu-\gamma\bar{z}) + n\tau_e i_j - (n\tau_e+\tau_v+\frac{\pi^2}{\gamma^2\sigma_z^2} - \frac{\pi}{\gamma^2\sigma_z^2})p] \tag{36}$$

Plug (35) in (26) shows that

$$\begin{aligned} A &= (\mathbb{E}(v|i_j,p)-p)^2[(n-1)^2\tau_e^2\mathrm{Var}(v|i_j,p) + \tau_e(n-1)] \\ &+ [\tau_v\bar{v} - \frac{\pi}{\gamma^2\sigma_z^2}(\mu-\gamma\bar{z}) + \tau_e i_j + (n-1)\tau_e\mathbb{E}(v|i_j,p) - (n\tau_e+\tau_v+\frac{\pi^2}{\gamma^2\sigma_z^2} - \frac{\pi}{\gamma^2\sigma_z^2})p]^2\mathrm{Var}(v|i_j,p) \\ &- 2(\mathbb{E}(v|i_j,p)-p)[\tau_v\bar{v} - \frac{\pi}{\gamma^2\sigma_z^2}(\mu-\gamma\bar{z}) + \tau_e i_j + (n-1)\tau_e\mathbb{E}(v|i_j,p) - (n\tau_e+\tau_v+\frac{\pi^2}{\gamma^2\sigma_z^2} - \frac{\pi}{\gamma^2\sigma_z^2})p] \\ &\times [1+(n-1)\tau_e\mathrm{Var}(v|i_j,p)] \\ B &= 1+(n-1)\tau_e\mathrm{Var}(v|i_j,p), \text{ and} \end{aligned}$$

$$\begin{aligned} \mathbb{E}(v|i_j,p) &= \frac{\gamma^2\sigma_z^2\tau_e i_j + \pi(p-\mu+\gamma\bar{z}) + \gamma^2\sigma_z^2\tau_v\bar{v}}{\gamma^2\sigma_z^2\tau_e + \pi^2 + \gamma^2\sigma_z^2\tau_v} \\ \mathrm{Var}(v|i_j,p) &= \frac{\gamma^2\sigma_z^2}{\gamma^2\sigma_z^2\tau_e + \pi^2 + \gamma^2\sigma_z^2\tau_v}. \end{aligned}$$

Futher simplification gives the expression for the expected utility of entrepreneur j. □

B Proof of Corollary 3.5

Proof of Corollary 3.5: When all entrepreneurs create firms, in a linear equilibrium, project valuation and entrepreneur investment still follows

$$\begin{aligned} \tilde{p} &= \mu + \pi \tilde{v} - \gamma \tilde{z} && (37) \\ x_k &= n\alpha_0 + n\alpha_1 i_k + n\alpha_2 p, \text{ for entrepreneur } k, && (38) \end{aligned}$$

where μ, π, γ and α_i $(i = 0, 1, 2)$ are all functions of n to be determined, and by the same arguments in the proof of Corollary 3.4, these coefficients satisfy (35).

Integrate each individual entrepreneurs' investment over the continuum and by market clearing,

$$n\alpha_0 + n\alpha_1 v + n\alpha_2(\mu + \pi v - \gamma z) + z = 0, \text{ thus} \tag{39}$$

$$\begin{cases} \alpha_0 = -\alpha_2 \mu \\ \alpha_1 = -\alpha_2 \pi \\ \alpha_2 = \frac{1}{n\gamma} \end{cases} \tag{40}$$

Plug in (35) and re-arrange terms,

$$\begin{cases} \mu = \frac{\sigma_z^2 \rho^2}{(n\tau_e + \tau_v)\sigma_z^2 \rho^2 + n^2 \tau_e^2} \left(\tau_v \bar{v} - \frac{n\tau_e}{\rho \sigma_z^2} \bar{z} \right) \\ \pi = -\frac{n\tau_e}{\rho} \gamma = \frac{n\tau_e (n\tau_e + \sigma_z^2 \rho^2)}{(n\tau_e + \tau_v)\sigma_z^2 \rho^2 + n^2 \tau_e^2} \\ \gamma = -\frac{n\tau_e \rho + \sigma_z^2 \rho^3}{(n\tau_e + \tau_v)\sigma_z^2 \rho^2 + n^2 \tau_e^2} \end{cases} \tag{41}$$

Plug in (36) and (26) and we get the optimal demand and expected payoff given in (17). □

C Proof of Lemma 4.1

Proof of Lemma 4.1. Once entered into a signal-sharing alliance, entrepreneur j's expected utility is given by

$$-\exp\left\{-\left[\tau_v\bar{v}-\tfrac{\pi}{\gamma^2\sigma_z^2}(\mu-\gamma\bar{z})+n\tau_e i^*-(n\tau_e+\tau_v+\tfrac{\pi^2}{\gamma^2\sigma_z^2}-\tfrac{\pi}{\gamma^2\sigma_z^2})p\right][\mathbb{E}(v|i^*,p)-p]+\right.$$
$$\left.\tfrac{1}{2}\left[\tau_v\bar{v}-\tfrac{\pi}{\gamma^2\sigma_z^2}(\mu-\gamma\bar{z})+n\tau_e i^*-(n\tau_e+\tau_v+\tfrac{\pi^2}{\gamma^2\sigma_z^2}-\tfrac{\pi}{\gamma^2\sigma_z^2})p\right]^2\mathrm{Var}(v|i^*,p)\right\} \tag{42}$$

Thus her expected utility before entering the alliance (but after receiving i_j) is

$$\begin{aligned}
&-\mathbb{E}\left\{\exp\left(-\left[\tau_v\bar{v}-\frac{\pi}{\gamma^2\sigma_z^2}(\mu-\gamma\bar{z})+n\tau_e i^*-(n\tau_e+\tau_v+\frac{\pi^2}{\gamma^2\sigma_z^2}-\frac{\pi}{\gamma^2\sigma_z^2})p\right][\mathbb{E}(v|i^*,p)-p]\right.\right.\\
&\left.\left.+\frac{1}{2}\left[\tau_v\bar{v}-\frac{\pi}{\gamma^2\sigma_z^2}(\mu-\gamma\bar{z})+n\tau_e i^*-(n\tau_e+\tau_v+\frac{\pi^2}{\gamma^2\sigma_z^2}-\frac{\pi}{\gamma^2\sigma_z^2})p\right]^2\mathrm{Var}(v|i^*,p)\right)\,\middle|\, i_j,p\right\}\\
=\;&-\mathbb{E}\left\{\exp\left(-\frac{1}{2}\frac{1}{n\tau_e+\frac{\pi^2}{\gamma^2\sigma_z^2}+\tau_v}\left[\tau_v\bar{v}-\frac{\pi}{\gamma^2\sigma_z^2}(\mu-\gamma\bar{z})+n\tau_e i^*-(n\tau_e+\tau_v+\frac{\pi^2}{\gamma^2\sigma_z^2}-\frac{\pi}{\gamma^2\sigma_z^2})p\right]^2\right)\,\middle|\, i_j,p\right\}\\
=\;&-\frac{\exp\left(-\frac{1}{2}\frac{1}{\tau_e+\frac{\pi^2}{\gamma^2\sigma_z^2}+\tau_v}\left[\tau_e i_j-\frac{\pi}{\gamma^2\sigma_z^2}(\mu-\gamma\bar{z})+\tau_v\bar{v}-(\tau_e+\tau_v+\frac{\pi^2}{\gamma^2\sigma_z^2}-\frac{\pi}{\gamma^2\sigma_z^2})p\right]^2\right)}{\sqrt{\frac{n\tau_e+\frac{\pi^2}{\gamma^2\sigma_z^2}+\tau_v}{\tau_e+\frac{\pi^2}{\gamma^2\sigma_z^2}+\tau_v}}}
\end{aligned}$$

The first equation is from (20), while the second one uses the following two facts:

1. If $x\sim\mathcal{N}(\mu,\sigma^2), \mathbb{E}[e^{Ax^2}]=\frac{\exp\left(\frac{A\mu^2}{1-2A\sigma^2}\right)}{\sqrt{1-2A\sigma^2}}$;
2. $\tau_v\bar{v}-\frac{\pi}{\gamma^2\sigma_z^2}(\mu-\gamma\bar{z})+n\tau_e i^*-(n\tau_e+\tau_v+\frac{\pi^2}{\gamma^2\sigma_z^2}-\frac{\pi}{\gamma^2\sigma_z^2})p\,\big|_{i_j,p}\sim$
   $$\mathcal{N}\left(\frac{n\tau_e+\frac{\pi^2}{\gamma^2\sigma_z^2}+\tau_v}{\tau_e+\frac{\pi^2}{\gamma^2\sigma_z^2}+\tau_v}\left[\tau_e i_j-\frac{\pi}{\gamma^2\sigma_z^2}(\mu-\gamma\bar{z})+\tau_v\bar{v}-(\tau_e+\tau_v+\frac{\pi^2}{\gamma^2\sigma_z^2}-\frac{\pi}{\gamma^2\sigma_z^2})p\right],\frac{n\tau_e+\frac{\pi^2}{\gamma^2\sigma_z^2}+\tau_v}{\tau_e+\frac{\pi^2}{\gamma^2\sigma_z^2}+\tau_v}(n-1)\tau_e\right)$$

□

D When Alliance Gets Large

To formally study the case of a monopoly firm, consider (17) as $n \to \infty$. For entrepreneur j

$$\begin{aligned}\lim_{n\to\infty} x_j &= \lim_{n\to\infty} \frac{1}{\rho}[\tau_v \bar{v} - n\tau_e(\frac{\tau_v\bar{v}+\rho\bar{z}}{n\tau_e+\sigma_z^2\rho^2}) + n\tau_e i_j - (n\tau_e + \frac{\rho^2\sigma_z^2\tau_v}{\rho^2\sigma_z^2+n\tau_e})p] \\ &= \pm\infty \text{ (depending on the sign of } i_j - p).\end{aligned}$$

In the case of a monopoly firm, even though each entrepreneur is still of measure zero, individual demand "looms" large. In another words, there does not exist an interior symmetric, linear equilibrium with a monopoly firm.

This counter-intuitive "no equilibrium" observation results from a failure of the price-taking assumption. In classic noisy rational expectation models, assuming agents to be price takers is a convenient approximation when the number of agents in the economy is large. This is because each agent's individual demand is negligible compared to the aggregate demand. It is thus fine to assume that no single agent can move the equilibrium price on her own. However this convenience is lost when agents are organized in a single large firm. As individual demand looms large, keep assuming that agents take prices as given and do not expect their demands to move equilibrium prices makes them susceptible to the well-known "schizophrenia" critique by Hellwig (1980).

A modified setup that takes into account firms' own price impact is similar to Kyle (1989). For ease of exposition, I start from a Bayesian Nash equilibrium among a finite number of n entrepreneurs, and consider the limiting case when $n \to \infty$. In this setup each entrepreneur's investment decision is to post a downward-sloping demand schedule, and the equilibrium price and quantities are determined by crossing the demand schedule with a residual supply curve, which summarizes the sum of other entrepreneurs' demands and the realization of the random demand nz.[29]

[29]There is a factor of n so that *per capita* random demand is still z.

Theorem D.1. *When a continuum of entrepreneurs form a monopoly firm, and each entrepreneur takes into account of her own price impact, there exists a symmetric, linear Bayesian Nash equilibrium in which each entrepreneurs optimal demand is given by*

$$x_j = \beta i_j - \gamma p, \text{ where} \tag{43}$$

β satisfies

$$\beta^4 + \beta^3 \rho \sigma_z^4 (\tau_e + \tau_v) - \beta \rho \sigma_z^4 (\tau_e + \tau_v) - \sigma_z^4 (\tau_e + \tau_v)^2 = 0 \tag{44}$$

and γ satisfies

$$\begin{aligned} & \{\rho\beta\sigma_z^4\tau_e(\tau_e+\tau_v)^2 + \rho\beta^3\tau_e + 2[\beta^2\tau_e + \tau_e\sigma_z^2(\tau_v+\tau_e) + \rho\beta\tau_e\sigma_z^2](\tau_e+\tau_v)\} \tfrac{\beta}{\sigma_z^2(\tau_e+\tau_v)+\beta^2}\gamma \\ = & \quad \rho\beta^3\tau_e + [\beta^2\tau_e + \tau_e\sigma_z^2(\tau_v+\tau_e) + \rho\beta\tau_e\sigma_z^2](\tau_e+\tau_v) \end{aligned}$$

Proof. I conjecture a linear symmetric equilibrium, in which entrepreneur j's demand schedule is given by

$$x_j = \mu + \beta i_j - \gamma p. \tag{45}$$

In a single large firm, entrepreneur j's expected payoff is given by

$$\mathbb{E}[-\exp(-\frac{\rho}{n}(v-p)(x_j + \sum_{k=1,k\neq j}^{n} x_k)|i_j, p)] \tag{46}$$

$$= \mathbb{E}[-\exp(\rho(v-p)z|i_j, p)] \tag{47}$$

$$(\quad \because \sum_{k=1}^{n} x_k + nz = 0 \text{ by market clearing }) \tag{48}$$

Because

$$\begin{pmatrix} v-p \\ \rho z \end{pmatrix}_{|i_j,p} \sim \mathcal{N}\left(\begin{array}{c} \begin{bmatrix} \mathbb{E}(v|i_j,p)-p \\ \rho\mathbb{E}(z|i_j,p) \end{bmatrix}, \\ \begin{bmatrix} \mathrm{Var}(v|i_j,p) & \rho\mathrm{Cov}(v,z|i_j,p) \\ \rho\mathrm{Cov}(v,z|i_j,p) & \rho^2\mathrm{Var}(z|i_j,p) \end{bmatrix} \end{array} \right), \tag{49}$$

by Lemma A.1 we have the expected utility of entrepreneur j to be

$$-\frac{\exp(\frac{A}{2B})}{\sqrt{B}}, \text{ where} \tag{50}$$

$$\begin{aligned} A &= \rho^2\mathbb{E}^2(z|i_j,p)\mathrm{Var}(v|i_j,p) + (\mathbb{E}(v|i_j,p)-p)^2\rho^2\mathrm{Var}(z|i_j,p) + \\ &\quad 2[1-\rho\mathrm{Cov}(v,z|i_j,p)][\mathbb{E}(v|i_j,p)-p]\rho\mathbb{E}(z|i_j,p) \\ B &= (\rho\mathrm{Cov}(v,z|i_j,p)-1)^2 - \rho^2\mathrm{Var}(z|i_j,p)\mathrm{Var}(v|i_j,p) \end{aligned}$$

$\because x_j + \sum_{k\neq j}(\mu + \beta i_k - \gamma p) + nz = 0$, with the knowledge of i_j, p is informationally equivalent to $\beta\sum_{k\neq j} i_k + nz$ for entrepreneur j.[30]

Notice that the covariance matrix of $(v, z, v+e_j, \beta(n-1)v + nz + \beta\sum_{k\neq j} e_k)$ is given by

$$\begin{pmatrix} \tau_v^{-1} & 0 & \tau_v^{-1} & \beta(n-1)\tau_v^{-1} \\ 0 & \sigma_z^2 & 0 & n\sigma_z^2 \\ \tau_v^{-1} & 0 & \tau_v^{-1}+\tau_e^{-1} & \beta(n-1)\tau_v^{-1} \\ \beta(n-1)\tau_v^{-1} & n\sigma_z^2 & \beta(n-1)\tau_v^{-1} & \beta^2(n-1)^2\tau_v^{-1} + n^2\sigma_z^2 + \beta^2(n-1)\tau_e^{-1} \end{pmatrix}, \tag{51}$$

[30] Specifically, $\beta\sum_{k\neq j} i_k + nz = (n-1)\gamma p - (n-1)\mu - x_j$.

whose inverse is

$$\begin{pmatrix} n\tau_e+\tau_v & \frac{n\tau_e}{\beta} & -\tau_e & -\frac{\tau_e}{\beta} \\ \frac{n\tau_e}{\beta} & \frac{\beta^2(n-1)+n^2\sigma_z^2\tau_e}{\beta^2(n-1)\sigma_z^2} & 0 & -\frac{n\tau_e}{\beta^2(n-1)} \\ -\tau_e & 0 & \tau_e & 0 \\ -\frac{\tau_e}{\beta} & -\frac{n\tau_e}{\beta^2(n-1)} & 0 & \frac{\tau_e}{\beta^2(n-1)} \end{pmatrix}. \tag{52}$$

Thus by the properties of multi-normal distributions we obtain the following conditional moments:

$$\left\{\begin{array}{rcl} \mathbb{E}(v|i_j,p) & = & \bar{v}+\frac{n^2\sigma_z^2\tau_e^2+\beta^2(n-1)\tau_e}{n^2\sigma_z^2\tau_e(\tau_e+\tau_v)+\beta^2(n-1)(n\tau_e+\tau_v)}(i_j-\bar{v}) \\ & & +\frac{\beta(n-1)\tau_e}{n^2\sigma_z^2\tau_e(\tau_e+\tau_v)+\beta^2(n-1)(n\tau_e+\tau_v)}[(n-1)\gamma p-(n-1)\mu-x_j-\beta(n-1)\bar{v}-n\bar{z}] \\ \mathbb{E}(z|i_j,p) & = & \bar{z}-\frac{\beta(n-1)n\sigma_z^2\tau_e^2}{n^2\sigma_z^2\tau_e(\tau_e+\tau_v)+\beta^2(n-1)(n\tau_e+\tau_v)}(i_j-\bar{v}) \\ & & +\frac{n\sigma_z^2\tau_e(\tau_e+\tau_v)}{n^2\sigma_z^2\tau_e(\tau_e+\tau_v)+\beta^2(n-1)(n\tau_e+\tau_v)}[(n-1)\gamma p-(n-1)\mu-x_j-\beta(n-1)\bar{v}-n\bar{z}] \\ \mathrm{Cov}(v,z|i_j,p) & = & \frac{-n(n-1)\beta\tau_e\sigma_z^2}{(n-1)\beta^2\tau_v+n(n-1)\beta^2\tau_e+n^2\tau_e\tau_v\sigma_z^2+n^2\tau_e^2\sigma_z^2} \\ \mathrm{Var}(z|i_j,p) & = & \frac{\beta^2(n-1)\sigma_z^2(\tau_v+n\tau_e)}{(n-1)\beta^2\tau_v+n(n-1)\beta^2\tau_e+n^2\tau_e\tau_v\sigma_z^2+n^2\tau_e^2\sigma_z^2} \end{array}\right. \tag{53}$$

Taking derivatives of (50) w.r.t. x_j we obtain that the optimal x_j satisfies:

$$\begin{array}{rl} & 2\rho^2\mathbb{E}(z|i_j,p)\mathrm{Var}(v|i_j,p)\frac{\partial}{\partial x_j}\mathbb{E}(z|i_j,p) \\ + & 2\left(\mathbb{E}(v|i_j,p)-p\right)\rho^2\mathrm{Var}(z|i_j,p)\frac{\partial}{\partial x_j}\mathbb{E}(v|i_j,p) \\ + & 2[1-\rho\mathrm{Cov}(v,z|i_j,p)]\frac{\partial}{\partial x_j}\mathbb{E}(v|i_j,p)\rho\mathbb{E}(z|i_j,p) \\ + & 2[1-\rho\mathrm{Cov}(v,z|i_j,p)]\left(\mathbb{E}(v|i_j,p)-p\right)\rho\frac{\partial}{\partial x_j}\mathbb{E}(z|i_j,p)=0 \end{array}$$

plug in the derivatives of (53) we get

$$\begin{aligned}
&- \quad 2\rho^2\mathbb{E}(z|i_j,p)\text{Var}(v|i_j,p)\frac{n\sigma_z^2\tau_e(\tau_e+\tau_v)}{n^2\sigma_z^2\tau_e(\tau_e+\tau_v)+\beta^2(n-1)(n\tau_e+\tau_v)} \\
&+ \quad 2\left(\mathbb{E}(v|i_j,p)-p\right)\rho^2\text{Var}(z|i_j,p)\left(-\frac{\beta(n-1)\tau_e}{n^2\sigma_z^2\tau_e(\tau_e+\tau_v)+\beta^2(n-1)(n\tau_e+\tau_v)}\right) \\
&+ \quad 2[1-\rho\text{Cov}(v,z|i_j,p)]\left(-\frac{\beta(n-1)\tau_e}{n^2\sigma_z^2\tau_e(\tau_e+\tau_v)+\beta^2(n-1)(n\tau_e+\tau_v)}\right)\rho\mathbb{E}(z|i_j,p) \\
&- \quad 2[1-\rho\text{Cov}(v,z|i_j,p)]\left(\mathbb{E}(v|i_j,p)-p\right)\rho\frac{n\sigma_z^2\tau_e(\tau_e+\tau_v)}{n^2\sigma_z^2\tau_e(\tau_e+\tau_v)+\beta^2(n-1)(n\tau_e+\tau_v)}=0
\end{aligned}$$

plug in the expressions for $\text{Cov}(v,z|i_j,p)$ and $\text{Var}(z|i_j,p)$ with further simplification leads to

$$\begin{aligned}
&- \quad \rho\mathbb{E}(z|i_j,p)\beta^2(n-1)\sigma_z^2(\tau_v+n\tau_e)n\sigma_z^2\tau_e(\tau_e+\tau_v) \\
&+ \quad \left(\mathbb{E}(v|i_j,p)-p\right)\rho\beta^2(n-1)\sigma_z^2(\tau_v+n\tau_e)\left(-\beta(n-1)\tau_e\right) \\
&+ \quad [(n-1)\beta^2(\tau_v+n\tau_e)+n^2\tau_e\sigma_z^2(\tau_v+\tau_e)+\rho n(n-1)\beta\tau_e\sigma_z^2] \\
&\qquad \times\left(-\beta(n-1)\tau_e\right)\mathbb{E}(z|i_j,p) \\
&- \quad [(n-1)\beta^2(\tau_v+n\tau_e)+n^2\tau_e\sigma_z^2(\tau_v+\tau_e)+\rho n(n-1)\beta\tau_e\sigma_z^2] \\
&\qquad \times\left(\mathbb{E}(v|i_j,p)-p\right)n\sigma_z^2\tau_e(\tau_e+\tau_v)=0
\end{aligned} \tag{54}$$

With the assumed entrepreneur j equilibrium demand $x_j=\mu+\beta i_j-\gamma p$, we have

$$\begin{cases}
\mathbb{E}(v|i_j,p) = \bar{v}+\frac{n^2\sigma_z^2\tau_e^2+\beta^2(n-1)\tau_e}{n^2\sigma_z^2\tau_e(\tau_e+\tau_v)+\beta^2(n-1)(n\tau_e+\tau_v)}(i_j-\bar{v}) \\
\qquad +\frac{\beta(n-1)\tau_e}{n^2\sigma_z^2\tau_e(\tau_e+\tau_v)+\beta^2(n-1)(n\tau_e+\tau_v)}[n\gamma p-\beta i_j-n\mu-\beta(n-1)\bar{v}-n\bar{z}] \\
\mathbb{E}(z|i_j,p) = \bar{z}-\frac{\beta(n-1)n\sigma_z^2\tau_e^2}{n^2\sigma_z^2\tau_e(\tau_e+\tau_v)+\beta^2(n-1)(n\tau_e+\tau_v)}(i_j-\bar{v}) \\
\qquad +\frac{n\sigma_z^2\tau_e(\tau_e+\tau_v)}{n^2\sigma_z^2\tau_e(\tau_e+\tau_v)+\beta^2(n-1)(n\tau_e+\tau_v)}[n\gamma p-\beta i_j-n\mu-\beta(n-1)\bar{v}-n\bar{z}]
\end{cases} \tag{55}$$

Plug in (54), as $n\to\infty$, further simplification and equalizing coefficients on both sides of the equation leads to:

from p-coefficients

$$\begin{aligned}&\{\rho\beta\sigma_z^4\tau_e(\tau_e+\tau_v)^2+\rho\beta^3\tau_e+2[\beta^2\tau_e+\tau_e\sigma_z^2(\tau_v+\tau_e)+\rho\beta\tau_e\sigma_z^2](\tau_e+\tau_v)\}\frac{\beta}{\sigma_z^2(\tau_e+\tau_v)+\beta^2}\gamma\\ =&\ \rho\beta^3\tau_e+[\beta^2\tau_e+\tau_e\sigma_z^2(\tau_v+\tau_e)+\rho\beta\tau_e\sigma_z^2](\tau_e+\tau_v)\end{aligned}$$

from i_j-coefficients we have

$$\beta^4+\beta^3\rho\sigma_z^4(\tau_e+\tau_v)-\beta\rho\sigma_z^4(\tau_e+\tau_v)-\sigma_z^4(\tau_e+\tau_v)^2=0$$

from constants we have

$$\mu=\frac{\begin{pmatrix}\beta^3\rho\sigma_z^4(\tau_e+\tau_v)+\beta^4\\ -\ \ \sigma_z^2(\tau_e+\tau_v)(\beta\rho\sigma_z^2+\sigma_z^2(\tau_e+\tau_v))\end{pmatrix}}{\begin{pmatrix}\rho\beta^2\sigma_z^6(\tau_e+\tau_v)^2+\rho\beta^2\sigma_z^2\beta^2\\ +\ \ 2[\beta^2+\sigma_z^2(\tau_v+\tau_e)+\rho\beta\sigma_z^2]\beta\sigma_z^2(\tau_e+\tau_v)\end{pmatrix}}(\bar{z}\beta-\bar{v}\sigma_z^2\tau_v)=0$$

□

By market clearing, we have that $p=\frac{1}{\gamma}(\beta v+z)$, thus with Theorem D.1, we have

$$p=\frac{\{\rho\beta\sigma_z^4\tau_e(\tau_e+\tau_v)^2+\rho\beta^3\tau_e+2[\beta^2\tau_e+\tau_e\sigma_z^2(\tau_v+\tau_e)+\rho\beta\tau_e\sigma_z^2](\tau_e+\tau_v)\}\beta}{\{\rho\beta^3\tau_e+[\beta^2\tau_e+\tau_e\sigma_z^2(\tau_v+\tau_e)+\rho\beta\tau_e\sigma_z^2](\tau_e+\tau_v)\}[\sigma_z^2(\tau_e+\tau_v)+\beta^2]}(\beta v+z)$$

Theorem D.1 shows that contrary to what is under the price-taking assumption, when own price impact is taken into account, the optimal demand of a member in a monopoly firm does not "loom large", even if the number of entrepreneurs in the economy approaches infinity. Without frictions in firm formation, this should be the expected market outcome of a Diamond and Verrecchia (1981)/Hellwig (1980) economy.

References

Adams, Renee B., and Daniel Ferreira, 2007, A theory of friendly boards, *The Journal of Finance* 62, 217–250. 27

Admati, Anat R, 1985, A noisy rational expectations equilibrium for multi-asset securities markets, *Econometrica: Journal of the Econometric Society* pp. 629–657. 5

Alchian, Armen A, and Harold Demsetz, 1972, Production, information costs, and economic organization, *The American economic review* pp. 777–795. 3, 7

Andrei, Daniel, and Julien Cujean, 2013, Information percolation, momentum, and reversal, . 26

Barberis, Nicholas, and Richard Thaler, 2003, A survey of behavioral finance, *Handbook of the Economics of Finance* 1, 1053–1128. 22

Beatty, Anne, 1995, The cash flow and informational effects of employee stock ownership plans, *Journal of Financial Economics* 38, 211–240. 23

Berk, Jonathan B, Richard Stanton, and Josef Zechner, 2010, Human capital, bankruptcy, and capital structure, *The Journal of Finance* 65, 891–926. 2

Berk, Jonathan B, and Johan Walden, 2013, Limited capital market participation and human capital risk, *Review of Asset Pricing Studies* 3, 1–37. 2

Bikhchandani, Sushil, David Hirshleifer, and Ivo Welch, 1992, A theory of fads, fashion, custom, and cultural change as informational cascades, *Journal of political Economy* pp. 992–1026. 26

Black, Fischer, 1986, Noise, *The journal of finance* 41, 529–543. 5

Bolton, Patrick, and Mathias Dewatripont, 1994, The firm as a communication network, *The Quarterly Journal of Economics* pp. 809–839. 4, 10

Bommel, Jos Van, 2003, Rumors, *The Journal of Finance* 58, 1499–1520. 26

Chakraborty, Archishman, and Bilge Yilmaz, 2010, Authority, consensus and governance, *Unpublished working paper. Wharton University, Philadelphia, PA*. 27

Chen, Qi, Itay Goldstein, and Wei Jiang, 2007, Price informativeness and investment sensitivity to stock price, *Review of Financial Studies* 20, 619–650. 3

Cheng, Si, Massimo Massa, Matthew Spiegel, and Hong Zhang, 2012, Human capital and the structure of the mutual fund industry, . 25

Coase, Ronald H, 1937, The nature of the firm, *economica* 4, 386–405. 3

Core, John E, and Wayne R Guay, 2001, Stock option plans for non-executive employees, *Journal of financial economics* 61, 253–287. 23

Demsetz, Harold, 1988, The theory of the firm revisited, *Journal of Law, Economics, & Organization* pp. 141–161. 4

Dewatripont, Mathias, and Jean Tirole, 2005, Modes of communication, *Journal of Political Economy* 113, 1217–1238. 11

Diamond, Douglas W, and Robert E Verrecchia, 1981, Information aggregation in a noisy rational expectations economy, *Journal of Financial Economics* 9, 221–235. 3, 5, 39

Dicks, David L., and Paolo Fulghieri, 2014, Ambiguity aversion, disagreement, and the theory of the firm, *Available at SSRN 2357599*. 4

Dong, Ming, David Hirshleifer, Scott Richardson, and Siew Hong Teoh, 2006, Does investor misvaluation drive the takeover market?, *The Journal of Finance* 61, 725–762. 22

Duffie, Darrell, Gaston Giroux, and Gustavo Manso, 2010, Information percolation, *American Economic Journal: Microeconomics* pp. 100–111. 26

Duffie, Darrell, Semyon Malamud, and Gustavo Manso, 2009, Information percolation with equilibrium search dynamics, *Econometrica* 77, 1513–1574. 26

——— , 2014, Information percolation in segmented markets, *Journal of Economic Theory*. 26

Duffie, Darrell, and Gustavo Manso, 2007, Information percolation in large markets, *The American economic review* pp. 203–209. 26

Edmans, Alex, Itay Goldstein, and John Y Zhu, 2011, Contracting with synergies, Discussion paper, National Bureau of Economic Research. 7

Erel, Isil, 2011, The effect of bank mergers on loan prices: Evidence from the united states, *Review of Financial Studies* 24, 1068–1101. 24

Fama, Eugene F, 1970, Efficient capital markets: A review of theory and empirical work*, *The journal of Finance* 25, 383–417. 4

García, Diego, and Joel M Vanden, 2009, Information acquisition and mutual funds, *Journal of Economic Theory* 144, 1965–1995. 13

Gaspar, José-Miguel, Massimo Massa, and Pedro Matos, 2006, Favoritism in mutual fund families? evidence on strategic cross-fund subsidization, *The Journal of Finance* 61, 73–104. 25

Goldstein, Itay, and Alexander Guembel, 2008, Manipulation and the allocational role of prices, *The Review of Economic Studies* 75, 133–164. 3

Graham, John R, Mark H Lang, and Douglas A Shackelford, 2004, Employee stock options, corporate taxes, and debt policy, *The Journal of Finance* 59, 1585–1618. 23

Grinblatt, Mark S, and Stephen A Ross, 1985, Market power in a securities market with endogenous information, *The Quarterly Journal of Economics* pp. 1143–1167. 3

Grossman, Sanford, 1976, On the efficiency of competitive stock markets where trades have diverse information, *The Journal of Finance* 31, 573–585. 4, 5, 6

Grossman, Sanford J, and Oliver D Hart, 1980, Takeover bids, the free-rider problem, and the theory of the corporation, *The Bell Journal of Economics* pp. 42–64. 22

———, 1986, The costs and benefits of ownership: A theory of vertical and lateral integration, *The Journal of Political Economy* pp. 691–719. 2, 3

———, 1988, One share-one vote and the market for corporate control, *Journal of financial economics* 20, 175–202. 22

Grossman, Sanford J, and Joseph E Stiglitz, 1980, On the impossibility of informationally efficient markets, *The American economic review* 70, 393–408. 3, 5

Hackbarth, Dirk, and Jianjun Miao, 2007, The dynamics of mergers and acquisitions in oligopolistic industries, *Washington University in St. Louis working paper.* 22

Harford, Jarrad, 1999, Corporate cash reserves and acquisitions, *The Journal of Finance* 54, 1969–1997. 22

———, 2005, What drives merger waves?, *Journal of financial economics* 77, 529–560. 21

Harris, Milton, and Artur Raviv, 2008, A theory of board control and size, *Review of Financial Studies* 21, 1797–1832. 27

Hart, Oliver, 1989, Economist's perspective on the theory of the firm, an, *Colum. L. Rev.* 89, 1775. 3

———, and John Moore, 1990, Property rights and the nature of the firm, *Journal of Political Economy* pp. 1119–1158. 3

Hellwig, Martin F, 1980, On the aggregation of information in competitive markets, *Journal of economic theory* 22, 477–498. 3, 4, 5, 13, 15, 34, 39

Hirshleifer, Jack, 1971, The private and social value of information and the reward to inventive activity, *The American Economic Review* 61, 561–574.

Holmström, Bengt, 1982, Moral hazard in teams, *The Bell Journal of Economics* pp. 324–340. 2

——— , and Jean Tirole, 1989, The theory of the firm, *Handbook of industrial organization* 1, 61–133. 3

——— , 1993, Market liquidity and performance monitoring, *Journal of Political Economy* pp. 678–709. 3

Ittner, Christopher D, Richard A Lambert, and David F Larcker, 2003, The structure and performance consequences of equity grants to employees of new economy firms, *Journal of Accounting and Economics* 34, 89–127. 23

Jensen, Michael C, and William H Meckling, 1979, *Theory of the firm: Managerial behavior, agency costs, and ownership structure* (Springer). 3

Kandel, Eugene, and Edward P Lazear, 1992, Peer pressure and partnerships, *Journal of political Economy* pp. 801–817. 7

Kempf, Alexander, and Stefan Ruenzi, 2008, Tournaments in mutual-fund families, *Review of Financial Studies* 21, 1013–1036. 25

Klein, Benjamin, Robert G Crawford, and Armen A Alchian, 1978, Vertical integration, appropriable rents, and the competitive contracting process, *Journal of law and economics* pp. 297–326. 3

Kyle, Albert S., 1985, Continuous auctions and insider trading, *Econometrica* 53, pp. 1315–1335. 3

Kyle, Albert S, 1989, Informed speculation with imperfect competition, *The Review of Economic Studies* 56, 317–355. 5, 6, 34

Lambrecht, Bart M, 2004, The timing and terms of mergers motivated by economies of scale, *Journal of Financial Economics* 72, 41–62. 21

Levit, Doron, 2012, Expertise, structure, and reputation of corporate boards, *Available at SSRN 1866384*. 27

Li, Jiasun, 2014, Slow price adjustment to public news in after-hours trading, *Available at SSRN 2379126*. 4

Lintner, John, 1965, The valuation of risk assets and the selection of risky investments in stock portfolios and capital budgets, *The review of economics and statistics* pp. 13–37. 9

Mailath, George J, and Larry Samuelson, 2006, Repeated games and reputations: long-run relationships, *OUP Catalogue*. 10

Malmendier, Ulrike, and Geoffrey Tate, 2008, Who makes acquisitions? ceo overconfidence and the market's reaction, *Journal of Financial Economics* 89, 20–43. 22

Markowitz, Harry, 1952, Portfolio selection*, *The journal of finance* 7, 77–91. 9

Mitchell, Mark L, and J Harold Mulherin, 1996, The impact of industry shocks on takeover and restructuring activity, *Journal of financial economics* 41, 193–229. 21

Modigliani, Franco, and Merton H Miller, 1958, The cost of capital, corporation finance and the theory of investment, *The American economic review* pp. 261–297. 3

Morellec, Erwan, and Alexei Zhdanov, 2005, The dynamics of mergers and acquisitions, *Journal of Financial Economics* 77, 649–672. 22

Myerson, Roger B, and Mark A Satterthwaite, 1983, Efficient mechanisms for bilateral trading, *Journal of economic theory* 29, 265–281.

Rajan, Raghuram G, 2012, Presidential address: The corporation in finance, *The Journal of Finance* 67, 1173–1217. 3, 4

———, and Julie Wulf, 2006, The flattening firm: Evidence from panel data on the changing nature of corporate hierarchies, *The Review of Economics and Statistics* 88, 759–773. 7

Rajan, Raghuram G., and Luigi Zingales, 1998, Power in a theory of the firm, *The Quarterly Journal of Economics*. 3

Rajan, Raghuram G, and Luigi Zingales, 2001, The firm as a dedicated hierarchy: A theory of the origins and growth of firms, *Quarterly Journal of Economics* pp. 805–851. 7

Rhodes-Kropf, MATTHEW, and David T Robinson, 2008, The market for mergers and the boundaries of the firm, *The Journal of Finance* 63, 1169–1211. 21

Rhodes-Kropf, Matthew, David T Robinson, and S Viswanathan, 2005, Valuation waves and merger activity: The empirical evidence, *Journal of Financial Economics* 77, 561–603. 22

Roll, Richard, 1986, The hubris hypothesis of corporate takeovers, *Journal of business* pp. 197–216. 21, 22

Ross, Stephen A, 2005, Markets for agents: fund management, *The Legacy of Fischer Black* p. 96. 13

Sharpe, William F, 1964, Capital asset prices: A theory of market equilibrium under conditions of risk*, *The journal of finance* 19, 425–442. 9

Shin, Hyun Song, 2010, *Risk and liquidity* (Oxford University Press). 3

Shleifer, Andrei, and Robert W Vishny, 2003, Stock market driven acquisitions, *Journal of financial Economics* 70, 295–311. 22

Spulber, Daniel F, 1999, *Market microstructure: intermediaries and the theory of the firm* (Cambridge University Press). 3

Summers, Lawrence H, 2014, Us economic prospects: Secular stagnation, hysteresis, and the zero lower bound, *Business Economics* 49, 65–73. 2

Titman, Sheridan, 2013, Financial markets and investment externalities, *The Journal of Finance* 68, 1307–1329. 3

Veldkamp, Laura L., 2011, *Information choice in macroeconomics and finance* (Princeton University Press).

Welch, Ivo, 1992, Sequential sales, learning, and cascades, *The Journal of finance* 47, 695–732. 26

Williamson, Oliver E, 1975, Markets and hierarchies, *New York* pp. 26–30. 3

———, 1979, Transaction-cost economics: the governance of contractual relations, *Journal of law and economics* pp. 233–261. 3

———, 1985, *The economic intstitutions of capitalism* (Simon and Schuster). 3

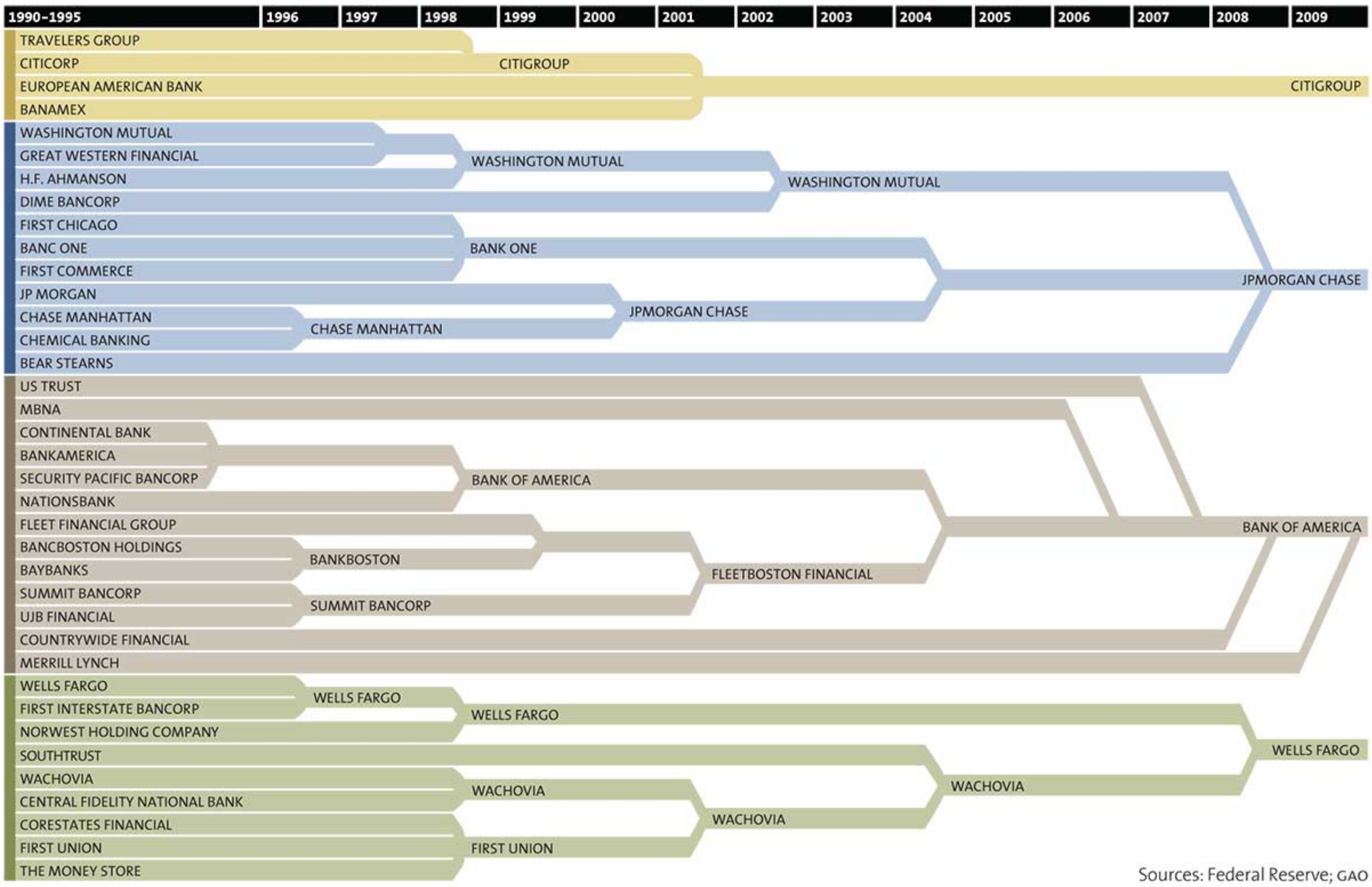
Winter, Eyal, 2006, Optimal incentives for sequential production processes, *The RAND Journal of Economics* 37, 376–390.

———, 2010, Transparency and incentives among peers, *The RAND Journal of Economics* 41, 504–523.

Zhang, Mindy Xiaolan, 2014, Who bears firm-level risk? implications for cash flow volatility, *WFA 2014 Monterey Meetings Paper*. 2

Zingales, Luigi, 2000, In search of new foundations, *The Journal of Finance* 55, 1623–1653. 2, 4

Figure 1: **The Making of the "Big-4" U.S. Banks through Mergers and Acquisitions**



Sources: Federal Reserve; GAO