Who Benefits from Innovations in Financial Technology?

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Abstract

Financial technology affect both efficiency and equity in the stock-market. The impact is non-trivial because several key innovations have altered multiple dimensions of investors' opportunity sets at the same time. For example, better and faster computing has made it (1) cheaper for retail investors to participate, and (2) to find funds that meet their needs, but also (3) cheaper for sophisticated investors to learn about asset returns. Some experts believe this may increase financial inclusion, others worry about possible anti-competitive effects that can lead to a more unequal wealth distribution. To settle this debate, I build a theoretical model of intermediated trading under asymmetric information that allows me to study each innovation in isolation. In the model, these changes have opposing implications for financial inclusion, competition, and inequality. The final outcome depends on which one dominates. Interpreting the data through the lens of my model suggests that the gains from financial technology were accruing to low-wealth investors before the 2000s, but they are now accruing to high-wealth investors. The reason this is happening is that even if investors have access to the equity premium through cheap funds, improvements in financial technology disproportionately benefit informed, big data players. This reduces the participation rate of low-wealth investors, improves price informativeness, enlarges (but consolidates) the active investment management industry and amplifies capital income inequality.

JEL codes: E21, G11, G14, L1, L15

Keywords: Financial technology; stock market; asset management; information; participation; inequality.

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1 Motivation

Progress in financial technology affects both efficiency/information and equity/participation in the stock market. Its impact is non-trivial because several key technological changes have altered multiple dimensions of investors' opportunity sets. For example, better and faster computing has simultaneously made it (1) cheaper for retail investors to participate, (2) and to find funds that meet their needs, but also (3) cheaper for sophisticated investors to learn private information about asset returns.[1] To understand the ultimate impact of innovations in financial technology on efficiency and equity, we need to care about which one of these dimensions is altered most. It appears commentators have disagreed about this, as evidenced by the disparate opinions of several experts in this field. Stiglitz (2014) believes financial technology will increase financial inclusion, while Philippon (2019) worries about its anti-competitive effects, and Piketty (2014) about possible unequal rent distribution.

To settle this debate, I build a theoretical model of intermediated trading under imperfect information that decomposes financial technological change into three distinct components: participation, search, and information acquisition costs. My model allows to study the effects of each in isolation. In my model, there is a continuum of two types of agents: investors and asset managers. Investors differ in their wealth and are uninformed. Asset managers are informed and trade in the best interest of their investors. Investors make two decisions: whether or not to pay a fixed cost of participation to enter the stock market, and whether or not to pay a search cost to find an informed manager with access to information that can improve return performance. While both investors and managers can acquire private information about the asset returns at a cost, due to economies of scale in asset management,[2] a natural outcome of my model is that no investor acquires private information directly. Investors optimally either invest directly and uninformedly (without any private signals) or indirectly and informedly, by delegating their portfolios to privately informed managers. In other words, the equilibrium of my model is characterized by two wealth thresholds that distinguish non-participating investors from those who invest directly uninformedly and those who invest indirectly informedly.

I then perform three comparative statics exercises to understand the impact of innovations in financial technology on stock market efficiency and equity. The first exercise is a decrease in the costs of stock market participation. The second is a decrease in search and matching costs which allows investors to perform due dilligence and vet the asset managers they choose to invest through. The third is a decrease in the costs of acquiring private information about the risky assets. Some of these aspects have been studied before, by Peress (2005), Bond and Garcia (2018), Kacperczyk et al. (2018), Garleanu and Pedersen (2018), and Davila and Parlatore (2019), but none has differentiated between all three. I argue that is important to separate these three aspects of financial technology because their effects and normative implications are starkly different and their interaction amplifies the economic mechanism I propose.

[1] Technology has reduced transaction and information costs (Puschmann and Alt (2016)), improved inclusion and transparency (Claessens et al. (2002)), facilitated risk-sharing among financial participants (Aron and Muellbauer (2019)), and reduced search frictions in markets for asset management (Lester et al. (2018)).

[2] Managers can spread the information costs among many investors. This can improve the returns of the poor and increase market efficiency (Garleanu and Pedersen (2018)).

In my model, improvements in participation, search and information processing costs have opposing implications for efficiency (i.e., information) and participation (i.e., risk-sharing). Lower participation costs make the stock market more inclusive by improving participation, but less efficient because of a rise in uninformed participation. Lower search and information costs make the stock market less inclusive because they reduce passive participation, but they also make it more efficient because of a rise in informed participation. Lower search costs also lead to a consolidation of the active investment management industry in the limit, because, when the stock market becomes almost perfectly efficient, one big manager extracts all the surplus. This tradeoff between efficiency and participation is explained in more detail below.

A lower participation cost leads to a natural rise in participation. However, this increase in participation lowers the incentives to delegate to informed managers because a fixed asset supply implies that stock prices go up for all assets. So, incumbent indirectly informed investors reduce their stock-holdings. The marginally indirectly informed investor, who was indifferent between investing directly uninformedly and delegating to a manager is now worse off. It becomes less attractive to pay the search cost to find an informed manager, because the gains from trade on a smaller portfolio fall. Overall expected returns fall, the equity premium falls, inequality decreases, and stock market prices become less informative because there are fewer indirectly informed investors.

A lower information cost implies that managers process more private information. Delegation fees fall, which incentivizes more investors to delegate their portfolios to informed managers. As the size of the asset management industry increases, price informativeness goes up because there are more indirectly informed investors, but crucially, uninformed participation falls. When the indirectly informed investor category grows, the marginally directly uninformed investor, who was indifferent between non-participation and investing directly uninformedly, now competes for the equity premium against more indirectly informed traders. It is no longer attractive to pay the participation fee just to invest uninformedly, because the gains from doing so are smaller. Therefore, marginally uninformed investors exit the stock market altogether and this amplifies inequality.

A lower search cost also allows a larger mass of investors to delegate to informed managers. Consequently, relatively lower-wealth investors, who were investing directly uninformedly and who do not benefit from the lower search cost, exit the stock market altogether, forgoing access to the equity premium. In a model extension with manager free-entry, lower search costs, unlike information costs, increase the concentration of the active asset management industry (i.e., the total revenue grows, but the number of managers falls). This is because the stock market becomes so efficient, that one big manager captures the entire market.

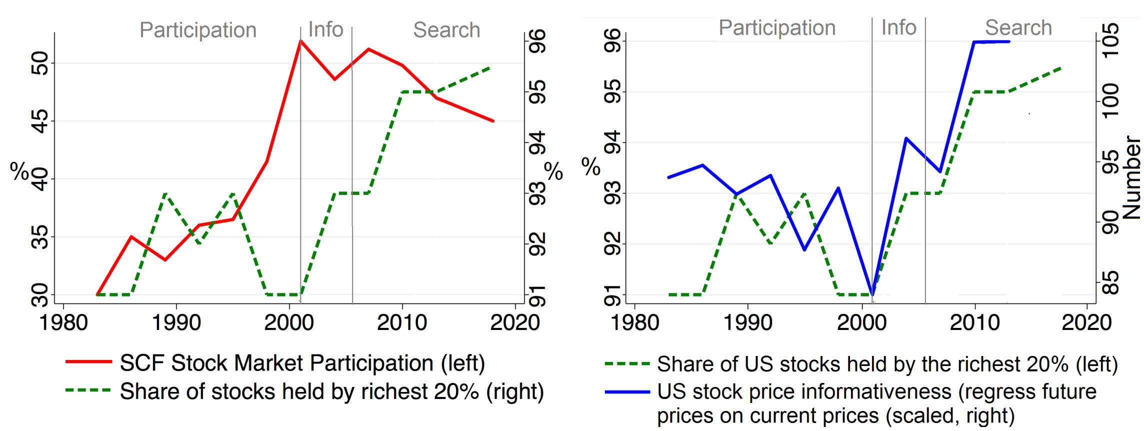
The net result on participation/equity and price informativeness/efficiency depends on which of these costs changes the most. The three comparative statics exercises discussed above emphasize a trade-off between information (i.e., efficiency) in financial markets and participation (i.e., risk-sharing). Improvements in financial technology are pulling this tradeoff one way or another. Knowing that their effects are different allows econometricians to use data to extract component-specific shocks to financial technology. Thus, this resolves the identification challenge discussed above.

To summarize, the key theoretical finding of my paper is that even if investors have access to cheap passive funds and even if stock market participation costs fall to zero in the limit, low-wealth investors are still going to exit the market if the search and information effects dominate. This is because low-wealth investors (i.e., who invest directly uninformedly) cannot compete with indirectly informed, big data traders. Improvements in financial technology make information-based trading more attractive than uninformed trading. Low-wealth uninformed investors end up competing with even more aggresively informed traders, which drive prices up and the returns from uninformed trading down. Directly uninformed investors no longer find it attractive to pay participation fees just to invest uninformedly, as the gains from doing so are smaller. Because uninformed trading becomes a worse option than before, the stock market participation of uninformed investors falls. This mechanism amplifies inequality, increases the equity premium, improves stock price informativeness, and leads to a larger (but possibly more concentrated) active asset management sector.

The data can help us think through which effect dominates over time. The data plotted in Figures (1) and (2) suggests that the early 2000s were a time of a technological U-turn in financial markets. While before 2000, participation was accelerating, since 2000, it has been falling. The fact that the wealthy hold more and more of the stock market suggests that it is the less-wealthy who are withdrawing from the stock market.[3] Price informativeness follows a U-shaped curve with its trough in 2000. Moreover, the number of hedge funds and their incentive fees were increasing before the 2000s when stock prices were not very informative (i.e., efficient), and have been decreasing rapidly since. These patterns in the data, viewed through the lens of my model, can be explained by the participation cost being more dominant before 2000, and the information and search costs dominating after 2000. I provide more evidence of this mechanism in Section (5).

Figure 1: **Participation effect drives entry up and price informativeness down before 2000. Search & Information effects drive them in the opposite direction after 2000.**

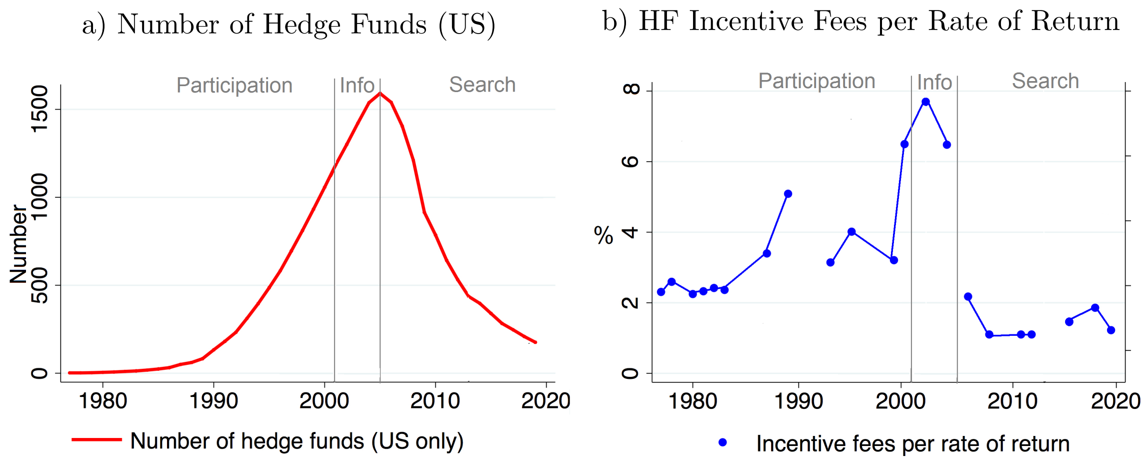
a) Participation Rate b) Price Informativeness



Legend: The share of stocks by top 20% capital wealth is from Saez and Zucman (2016). Stock market participation (weighted) is from SCF and includes direct and indirect holdings. Bai et al. (2016) compute stock price informativeness by running cross-sectional regressions of future earnings on current market prices.

[3]This is also documented by Kacperczyk et al. (2018).

Figure 2: **Participation effect drives number of hedge funds and their fees up before 2000. Search effect drives them down after 2000.**



Source: Lipper TASS Hedge Fund Database.

Interpreting the data through the lens of my model suggests that the gains from financial technology were accruing to low-wealth investors before the 2000s, but they are now accruing to high-wealth investors. The reason this is happening is that even if investors have access to the equity premium through cheap funds, improvements in financial technology disproportionately benefit informed, big data players. This reduces the participation rate of low-wealth investors, improves price informativeness, enlarges (but consolidates) the active investment management industry and amplifies capital income inequality. Fagereng et al. (2016), Di Maggio et al. (2018), and Campbell et al. (2018) provide evidence that wealthy investors already achieve higher Sharpe-ratios, while low-wealth investors lose money in the stock market. Moreover, the percentage of households delegating their investment portfolios increases with investors' initial wealth. The two phenomena are clearly related, and the idea is that wealthier investors benefit from searching for informed managers, since their search cost is low relative to their capital. And while passive funds have been a popular option for low-wealth investors, they are not the right vehicle to earn high payoffs. Leon Cooperman, the famed CEO of Omega Advisors has been saying for years that *"The wealthy didn't get to their net worth by buying an index."* I expect to continue to see an amplification of capital wealth inequality and polarization of capital returns due to financial technology.

The paper proceeds as follows. Section (2) places the contribution in the literature. Section (3) explains the model and the solution. Section (4) details the effects of technological innovations on the wealth distribution. Section (5) interprets the data through the lens of the model. Section (6) develops implications for policy and regulation. Section (7) concludes.

2 Contribution to Existing Literature

My paper contributes to the literatures on household finance, information economics, technological innovations, and investment management.

First, my paper relates to the stock-market participation literature in household finance. Participation costs encompass a number of different things, such as paying signup fees, time spent understanding and filing the necessary paperwork associated with stockholdings, and downloading e-trading apps. Participation matters not only for capital income inequality but also for price volatility (Allen and Gale (1994)) and for the efficiency of monetary policy (Morelli (2019)). Lusardi et al. (2017) argue that investors who have low financial literacy are significantly less likely to invest in stocks. Financial education has been proposed regularly as one way of increasing participation (van Rooij and Alessie (2011)).

My paper contributes to this. I argue that lower participation costs are not enough to improve participation rates. When information technologies lower the incentives for participation, additional solutions are needed.

Second, my paper adds to the literature on endogenous information acquisition in financial markets (Grossman and Stiglitz (1980), Verrecchia (1982), Kyle (1985), Admati and Pfleiderer (1990), Veldkamp (2006), and Peress (2010)). Noisy rational expectations models with endogenous information costs are a useful framework for thinking about the impact of the information revolution. They facilitate the study of complex general equilibrium effects while remaining highly tractable. Generally, these papers find that better information increases price informativeness and market efficiency.

I contribute to this literature by disentangling information itself into two components: information about hedge fund managers (modeled as a search cost) and information about assets (modeled as an information cost). The two generate different results in the model, and their coexistence explains the data better. Only cheaper information about managers drives, in the model, the drop in the number of hedge fund managers observed in the data.

I build on the modeling framework of Peress (2005), which is successful in explaining the rise in stock-market participation and the rise in passive investing before the 2000s. However, the focus is not on the decline in stock-market participation since the 2000s. I base my model on this framework because it generates a tradeoff between participation and information, which is useful for explaining the data before and *after* 2001. I employ a similar setting with heterogeneity in absolute risk aversion, to which I add a market for asset management, and distinguish between information about managers and information about assets. I use the model to study the effects of new technologies on price efficiency, the market structure of the asset management industry, and capital income inequality.

Similar to Peress (2005), Bond and Garcia (2018) look at the impact of a fall in the cost of participation over time. While this leads to more indexing, it does not explain the fall in participation in the last 20 years (i.e., the retrenching of low-wealth investors). The key missing ingredient is the lack of information technology effects. I do look at the impact of lower information costs, both for managers and for investors searching for managers, and trace out effects for capital income inequality, which could be extracted from Bond and Garcia (2018) but are not the focus there.

It has been known since Arrow (1987) that endogenous information acquisition amplifies wealth inequality. This property of information has been extended to discrete choice models (see Kacperczyk et al. (2018)) and continuous-time models (see Kasa and Lei (2018) and Lei (2019)) and shown to hold without loss of generality. Kacperczyk et al. (2018) is perhaps the most closely related paper, as it also studies inequality in a portfolio choice model where technological change improves the information constraints. I extend this literature by separating information into information about managers (modeled as search costs) and information about assets. These two types of information have very different implications. My model also has two additional amplification mechanisms for inequality due to the participation margin and the market structure of the investment management industry. Thus, one can potentially test empirically which mechanism is stronger.

Third, my paper extends the theoretical literature on the macroeconomic implications of technological innovations. The majority of existing work has focused on the impact of automation on labor income inequality through skill-biased technological change (Aghion et al. (2019), Acemoglu and Restrepo (2017), Autor et al. (2017), Martinez (2018)).

My paper extends this discussion by considering the impact of technological change on capital markets through information effects.[4] My contribution to this literature is theoretical. I show that innovations to information technologies can increase capital wealth inequality, consistent with empirical evidence by Ellis (2016), Dyck and Pomorski (2016) and Brei et al. (2018).

Lastly, my paper contributes to the literature on investment management. The benchmark paper is Berk and Green (2004) which studies the implications of fully efficient asset management markets in the context of exogenous and inefficient asset prices. I extend the analysis to consider an imperfect market for asset management due to search and information frictions. I use elements from Garleanu and Pedersen (2018), who find that the efficiency of asset prices is linked to the efficiency of the asset management market. Using a model where ex-ante identical investors can invest directly or search for an asset manager, Garleanu and Pedersen (2018) find that when investors can find managers more easily, more money is allocated to active management, fees are lower, and asset prices become more informative. While the model generates a number of verifiable predictions, it does not say anything about capital income inequality over time, or about the rate of stock market participation. It does not have a margin for participation; hence, there is no tradeoff between information and participation.

My contribution is to add a margin for participation and show that there is a tradeoff between information (i.e., efficiency) and participation (i.e., risk-sharing) and that this tradeoff is significant: It amplifies capital wealth inequality.

[4]As opposed to Schumpeterian theory, in which growth is driven by quality-improving innovations which destroy the rents generated by previous ones, I lay down a theory in which the value extracted from cost-saving innovations is different for the rich and the poor, allowing the rich to extract even more surplus from their investments. While Bilias et al. (2017) emphasizes that increased access to a risky financial instrument offering an expected return premium can reduce wealth inequality, Favilukis (2013) shows that there is a conflict between participation, which lowers inequality by making the equity premium available to more investors, and stock market booms, which widen the wealth gap between stockholders and non-stockholders.

3 Model

3.1 Setup: Market Players, Assets, Information, and Timing

This is a model wherein investors heterogeneous in initial wealth participate in trading risky assets by either investing directly or searching for an asset manager, information about assets is costly, and managers charge an endogenous fee.

Investors and Managers. The economy features a continuum of investors indexed by j, who differ in their initial wealth $W_{0j} \in [0, W_0^{max}]$, a continuum of mass one of asset managers indexed by m, who trade on behalf of groups of investors. There are also some noise traders who make random trades in the financial market for liquidity reasons.

Assumption 1 ***(Participation cost)***
Each investor must pay a fixed cost of participation, $F > 0$, to enter the stock market. If an investor chooses not to pay the fixed cost $F > 0$, she/he can only invest in bonds.

Then, each investor can either (a) invest directly in asset markets after having acquired costly private signals, (b) invest directly in asset markets without the signals, or (c) invest through an asset manager. Due to economies of scale, a natural equilibrium outcome is that investors do not acquire the signals themselves but rather invest uninformedly or through a manager. I will highlight weak conditions under which all realistic equilibria take this form and rule out that investors acquire the signals (see the Appendix).

The economy also has a continuum of mass one of asset-management firms, indexed by m. These asset-management firms are akin to family-owned offices/exclusive hedge funds that provide tailored advice to their investors and invest according to their investors' risk preferences. I assume that all asset managers are informed and that this fact is public knowledge. To invest with an informed asset manager, investors must search for and vet managers, which is a costly activity.

Assumption 2 ***(Search cost)***
The cost of finding an informed manager and confirming that the manager has the technology to acquire private information (i.e., performing due diligence) is $\omega > 0$.

The search cost ω captures the realistic feature that most investors spend significant resources finding an asset manager that they trust with their money. The form of this cost function does not matter, and for the moment, we can assume it is fixed for all investors.

Each investor solves a portfolio choice problem to maximize a mean-variance approximation of CRRA utility with a risk-aversion coefficient that declines with initial wealth. Investors' preferences are

$$\max_{q_j} \; E_j(W_{2j}) - \frac{\rho(W_{0j})}{2} Var_j(W_{2j}) \tag{1}$$

where W_{2j} is terminal wealth; W_{0j} is initial wealth; the coefficient of absolute risk aversion is $\rho(W_{0j}) = \frac{\rho}{W_{0j}} > 0$, with $\partial\rho(W_{0j})/\partial W_{0j} < 0$.

This preference specification can be interpreted as a local quadratic approximation of any utility function around initial wealth, and it allows for wealth effects, similar to CRRA utility. The heterogeneity in absolute risk aversion implies differences in the size of investors' risky portfolios and hence different gains from investing wealth in purchases of information. With strictly CARA preferences, investors would have collected the same amount of information regardless of the number of shares supplied and the mass of participating investors in equilibrium. With this CARA approximation of CRRA, however, the demand for information increases with the number of shares each investor expects to hold, reflecting the increasing returns to scale displayed by the production of information.

When an investor meets an asset manager and confirms that the manager has the technology to obtain private information, they negotiate the asset management fee f_j. The fee f_j is an equilibrium outcome set through Nash bargaining. For tractability, I assume that at the bargaining stage, the manager's information acquisition cost and the investor's search cost are sunk.

Assets and Information. The financial market consists of one risk-free asset in unlimited supply, with price normalized to 1 and payoff r, and one risky asset, with price p and a stochastic payoff z.[5]

$$z = \mu_z + \epsilon, \text{ with } \epsilon \sim N(0, \sigma_z^2) \tag{2}$$

Finally, the economy features a group of non-optimizing "noise traders," who trade for reasons independent of payoffs or prices (e.g., for liquidity or hedging reasons). This assumption ensures that prices do not reveal the private information endogenously acquired. Noisy traders provide a stochastic supply for the risky asset:

$$x = \mu_x + v, \text{ with } v \sim N(0, \sigma_x^2) \tag{3}$$

Market participants know the distribution of shocks but not their realizations. Prior to making portfolio decisions, market participants can obtain private information about the risky payoff in the form of private signals about z. I assume that the private signal is independent among market participants and given by

$$\mathbb{s}_j = z + \delta_j, \text{ where } \delta_j \sim N(0, \sigma_{s,j}^2) \tag{4}$$

Assumption 3 ***(Information acquisition cost)***
Each signal costs $\kappa(\sigma_{s_j}^{-2})$ to acquire, and the cost function increases in the precision of information learned such that $\kappa'(\sigma_{s,j}^{-2}) > 0$.

$$\kappa(\sigma_{s,j}^{-2}) = \frac{1}{2} c_0 (\sigma_{s,j}^{-2})^2 + c_1 \sigma_{s,j}^{-2} \text{ where } c_1 > 0 \text{ is a strictly positive constant}$$

The information set of an agent with no private information is $I(z; p)$, and the information set of an agent that acquires private information is $I(z; s, p)$.

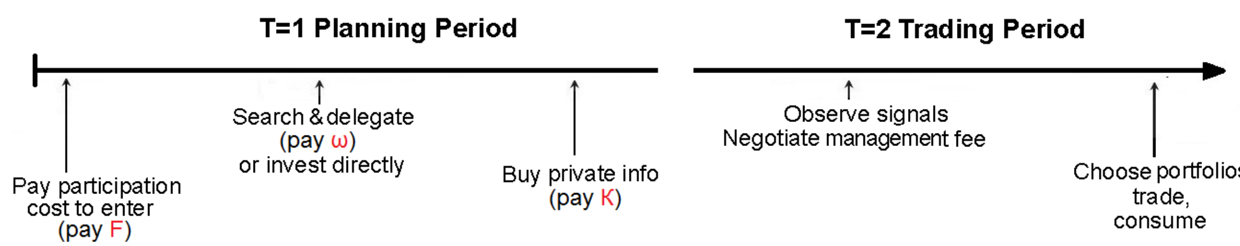
Timing. Each period is divided into two sub-periods, as shown in Figure (3).

[5] In the Appendix, I consider an extension with multiple risky assets ($N \geq 2$), where the payoffs are independent of each other. The economic mechanism and the results remain unchanged, although with small modifications to the assumptions, one can generate different results such as specialization vs. broadening of knowledge, etc.

In the first sub-period, investors decide whether to enter the stock market at a fixed cost, $F > 0$, that grants access to purchasing the risky asset. Then, investors choose whether to manage their portfolios individually or delegate to an informed asset manager. To invest with an informed asset manager, investors much search for and vet managers (i.e., perform due diligence), which is a costly activity, $\omega > 0$. Investors who manage their portfolios on their own and asset managers choose how much private information to learn about the risky asset. Learning private information costs $\kappa > 0$.

In the second sub-period, all market participants observe stock prices, learn the private signals they have chosen to acquire, and form their portfolios of assets. Investors who have chosen to delegate their portfolios now negotiate an asset management fee, $f > 0$ with their managers. As all trading is realized and the market clears, investors get their corresponding investment portfolios back for consumption. In the next period, investors start again with initial wealth equal to the terminal wealth from the previous period (but they do not optimize their decisions across periods).

Figure 3: **Timing of the game**



3.2 Equilibrium

Definition: An equilibrium of this noisy rational expectations economy consists of portfolio allocations q_j, precision levels $\hat{\sigma}_{s,m}^{-2}$, asset prices p, and asset management fees f_j, such that:

1. The allocations solve each investor's portfolio maximization problem.
$$\max_{q_j} \; E_j(W_{2j}) - \frac{\rho(W_{0j})}{2} Var_j(W_{2j}) \tag{5}$$
$$\text{subject to } W_{2j} = rW_{0j} - \mathbb{1}_{particip}[F - \mathbb{1}_{search}(\omega + f_j)] + q_j(z - rp) \tag{6}$$

2. Asset markets clear, such that the demand for the risky asset equals the stochastic supply.

3. Asset management fees are the outcome of Nash Bargaining such that no investor would like to switch status from searching for a manager or not.

4. The managers' chosen precisions solve their endogenous information acquisition problem such that the marginal benefit of acquiring information equals the marginal cost.

To solve and characterize the properties of this equilibrium, I work backwards, starting from the equilibrium in financial markets, then the equilibrium in the market for asset management, and then solving for the managers' endogenous information acquisition choices. Since the model involves several fixed costs, this economy will be characterized by a threshold equilibrium. The complete solution steps and proofs are in the Appendix. Below, I briefly outline the main results.

Asset Market Equilibrium. Every trader invests an amount in the risky asset that is proportional to the ratio of the expected excess return to the variance of the return given the information set, where the factor of proportionality is the risk tolerance: $1/\rho(W_{0j}) = W_{0j}/\rho$. Hence, an investor with twice the wealth buys twice the number of shares, either directly or through the asset manager.

Proposition 1 ***(Optimal portfolios)***
The optimal portfolio is given by $q_j^{directly} = \frac{\hat{\mu}^U_{z,j} - rp}{\rho(W_{0j})\hat{\sigma}^{U,2}_{z,j}}$ *for traders who trade on their own uninformedly, and by* $q_j^{delegate} = \frac{\hat{\mu}^I_{z,j} - rp}{\rho(W_{0j})\hat{\sigma}^{I,2}_{z,j}}$ *for traders who delegate to informed managers.*

I will now define some objects that will be useful going forward. Let t be the total risk-tolerance of all stock market participants. Let s be the informativeness of the price implied by aggregating the precision choices of those investors who delegate their portfolios to asset managers, who can be informed or uninformed. Let $n = s^{-1}$ be the total amount of noise in this economy. Note that due to economies of scale (see the Appendix for some conditions on the parameters), a natural equilibrium outcome is that investors do not acquire the signal directly: They either invest individually and uninformedly or delegate to informed managers.

$$t = \int_{W_0^{Particip}}^{W_0^{max}} \frac{1}{\rho(W_{0j})} dj; \qquad s = \int_{W_0^{Search}}^{W_0^{max}} \frac{1}{\rho(\bar{W_{0j}})\sigma^2_{s,m}} dj; \qquad n = \frac{1}{s}; \tag{7}$$

Market clearing implies that demand for the risky asset equals its stochastic supply. This relation gives rise to the formula for the stock price.

Proposition 2 ***(Asset price)***
The price of the risky asset is given by $rp = a + bz - cx$, *where*

$$a = \bar{h}^{-1}\left(\frac{\mu_z}{\sigma_z^2} + s\frac{\mu_x}{\sigma_x^2}\right); \qquad b = \bar{h}^{-1}\left(s^2\sigma_x^{-2} + \frac{s}{t}\right); \qquad c = \bar{h}^{-1}\left(s\sigma_x^{-2} + \frac{1}{t}\right); \tag{8}$$
$$\text{where } \bar{h} = \left(\frac{s}{t} + \sigma_z^{-2} + s^2\sigma_x^{-2}\right)$$

The price crucially depends on the ratio s/t, which becomes important for what is to follow. This is the ratio of the mass of searching investors (who get matched with an informed asset manager) to the mass of participating investors. Intuitively, it is the ratio between the total amount of information in the market and the total risk-sharing in the economy.

Management Fees. The asset management fee f_j is set through Nash bargaining between an investor and a manager. The fee depends on an investor's best outside option, which is the larger of the utility of investing on his/her own uninformedly and the utility of searching for another manager.

Definition 1 *Let θ be the market inefficiency:*

$$\theta = \rho(W_{0j}) \left(U_{1j}^{delegate} - U_{1j}^{directly} \right) \tag{9}$$

The market inefficiency records the amount of uncertainty about the asset value for an agent, who only knows the price, relative to the uncertainty remaining when the agent knows both the price and the private signal s_j. The price inefficiency $\theta \geq 0$ is a positive number. Naturally, a higher θ corresponds to a more inefficient market, while zero inefficiency corresponds to a price that fully reveals the private signal. The price inefficiency θ is linked to managers' and investors' value of information. It gives the relative utility of investing based on the manager's information ($U_{1j}^{delegate}$) versus investing uninformedly ($U_{1j}^{directly}$).

The fee f_j is determined through Nash bargaining, maximizing the product of the utility gains from agreement. If no agreement is reached, the investor's outside option is to invest uninformedly on his/her own, yielding a utility of $(rW_{0j} - F - \omega + U_{1j}^{directly})$. The utility of searching for another manager is $(rW_{0j} - F - \omega - f_j + U_{1j}^{delegate})$. For an asset manager, the gain from agreement is the fee f_j, as the cost of acquiring information $\kappa(.)$ is sunk, and there is no marginal cost of taking on the investor. The bargaining problem is to maximize the surplus, which is given by $(U_{1j}^{delegate} - U_{1j}^{directly} - f_j)f_j$. The optimality condition gives the fee schedule for all investors j.

Proposition 3 ***(Asset management fee)***
The asset management fee is given by f_j. It increases with the level of market inefficiency and with the investor's initial wealth.

$$f_j = \frac{\theta}{2\rho(W_{0j})} \tag{10}$$

It is easy to see that the management fee increases with the market's inefficiency, $\frac{\partial f_j}{\partial \theta} = \frac{1}{2\rho(W_{0j})} > 0$, and with the investor's initial wealth, $\frac{\partial f_j}{\partial W_{0j}} = \frac{\theta}{2\rho} > 0$. The fee would naturally be zero if asset markets were perfectly efficient, so that investors had no benefit from searching for an informed manager. In this setting, active asset management fees can be construed as evidence that retail investors believe that securities markets are not fully efficient.

Investors' Decision to Search for Informed Managers. An investor optimally decides to look for an informed asset manager as long as the utility difference from doing so is at least as large as the cost of searching and paying the asset management fee:

$$U_{1j}^{delegate} - U_{1j}^{directly} \geq \omega + f_j \tag{11}$$

Using equation (9), this translates to $\frac{\theta}{\rho(W_{0j})} \geq \omega + f_j$. This relation must hold with equality in an interior equilibrium. Plugging in the equilibrium management fee, this implies $\omega = \frac{\theta}{2\rho(W_{0j})}$.

To solve for the market inefficiency, θ, one needs to first compute the expected utility. Ex-ante utility is given by $U_{1j} = rW_{0j} - F - \omega - \mathbb{1}(f_j) + \frac{1}{2\rho(W_{0j})} E_1[(\frac{\hat{\mu}_{z,j} - rp}{\sqrt{\hat{\sigma}^2_{z,j}}})^2]$.

The Appendix goes over this exercise step by step; for brevity, I mention here that the ex-ante expectation of time-1 utility is

$$U_{1j} = \max_{\sigma_{s,j}^{-2}} rW_{0j} - F - \omega - \mathbb{1}(f_j(\sigma_{s,j}^{-2})) + \frac{1}{2} \frac{\left(\sigma_{s,j}^{-2} + \sigma_z^{-2} + s^2 \sigma_x^{-2}\right) D - 1}{\rho(W_{0j})} \tag{12}$$

$$\text{where} \quad D = \left(\frac{1}{t^2 \left[\frac{s}{t} + \sigma_z^{-2} + s^2 \sigma_x^{-2} \right]^2} \right) \left[E(x^2) + t^2 \left(\sigma_z^{-2} + s^2 \sigma_x^{-2} \right) + 2ts \right] \tag{13}$$

Note that the objective function in (12) captures the information choice tradeoff. Higher precision $\sigma_{s,j}^{-2}$ leads to higher asset management fees f_j, thereby reducing ex-ante utility. On the other hand, higher precision increases the posterior precision $\hat{\sigma}_{z,j}^{-2}$, which increases the time-1 expected squared Sharpe ratio $E_1\left[\eta_j^2\right]$ and thus ex-ante utility.

Proposition 4 ***(Benefit of learning private information)***
The benefit of learning private information, D, *decreases as more investors search for informed asset managers (i.e., as* s *increases and prices become more informative), decreases as the total risk-tolerance of investors who participate in the stock market increases (i.e., as* t *increases), and increases with the amount of noise in the economy (i.e., as* n *increases).*

Proof: See the Appendix. I show that $\frac{\partial D}{\partial s} < 0$, $\frac{\partial D}{\partial t} < 0$, and $\frac{\partial D}{\partial n} > 0$.

In other words, as prices reveal more information, acquiring costly private information becomes less beneficial. Similarly, learning costly private information pays off when aggregate risk-tolerance is low and investors are more risk-averse (holding less of the risky asset).

Noting that $u_{1j}^{delegate} - u_{1j}^{directly} = \frac{1}{2} \frac{\sigma_{s,j}^{-2} D}{\rho(W_{0j})}$, the price inefficiency is given by

$$\theta = \frac{\sigma_{s,j}^{-2} D}{2} = \frac{\sigma_{s,j}^{-2}}{2} \left(\frac{E(x^2) + t^2 \left(\sigma_z^{-2} + s^2 \sigma_x^{-2} \right) + 2st}{t^2 \left[\frac{s}{t} + \sigma_z^{-2} + s^2 \sigma_x^{-2} \right]^2} \right) \tag{14}$$

Managers' Endogenous Information Choice. A prospective informed manager must pay a cost $\kappa(\hat{\sigma}_{s,m}^{-2})$ to acquire information about the risky asset. On the other hand, by becoming informed, the manager can expect to get more investors. A manager chooses how much to learn, $\sigma_{s,m}^{-2}$, by equating the cost of learning to the benefit of learning. I assume a quadratic form for the cost of acquiring information about the risky asset: $\kappa(\sigma_{s,m}^{-2}) = \frac{1}{2} c_0 (\sigma_{s,m}^{-2})^2 + c_1 \sigma_{s,m}^{-2}$. The cost increases with the precision of the information learned. This means that more precise information is more costly to acquire.

For a manager, the benefit of learning is the fee obtained from all the investors delegating to that manager. There is a total mass one of managers, and the cost of learning is $\kappa(\sigma_{s,m}^{-2})$. Thus, in an interior equilibrium, the manager's marginal benefit of learning (i.e., fees from extra delegating investors) has to equal his/her marginal cost of learning (i.e., marginal cost of information acquisition). In other words, $\frac{sD}{4} = \kappa'(\sigma_{s,m}^{-2})$.

Proposition 5 ***(Optimal learning)***
The managers' optimal precision choice is given by:

$$\sigma_{s,m}^{-2} = \frac{sD - 4c_1}{4c_0} \tag{15}$$

A manager's individual precision choice naturally decreases with the costs of acquiring information (i.e., with c_1 and c_0). The more expensive information is, the lower the precision acquired. A manager's precision is also a concave function of s and a convex function of n.

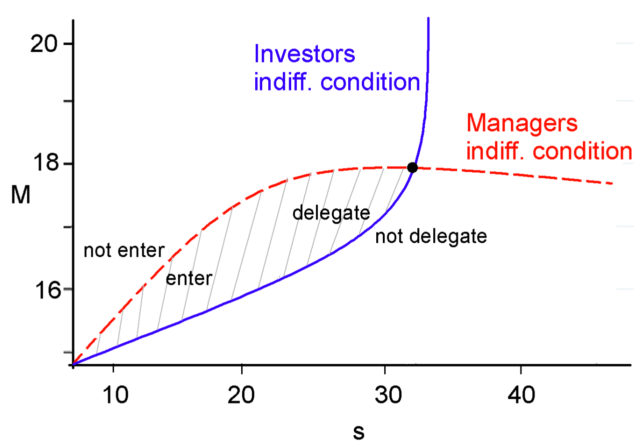
Free Entry of Managers. I will now derive the managers' information choice, assuming free entry in the industry for asset management. Let M be the mass of active managers. For an uninformed manager to enter, the expected extra fee revenue has to cover the cost of information, $\frac{sD}{4M} \geq \kappa'(\sigma_{s,m}^{-2})$. This condition has to hold with equality for an interior equilibrium.

Proposition 6 ***(Number of managers)***
The number of managers is given by

$$M = \frac{sD}{4\kappa'(\sigma_{s,m}^{-2})}$$

With free entry, the equilibrium for assets and asset management is given by the managers' and delegating investors' indifference conditions. Figure (4) shows the equilibrium in the space (s, M).

Figure 4: **Equilibrium for assets and asset management**



The blue full line is the investors' indifference condition between investing uninformedly and delegating to an informed manager. The red dashed line is the managers' indifference condition between entering informedly and not entering the industry. In an interior equilibrium, the two lines intersect away from $(0, 0)$.

The blue line is the investors' indifference condition for searching and delegating to an asset manager. When (s, M) is above and to the left of the solid blue line, investors prefer to search for and delegate to asset managers because managers are attractive to find due to the limited efficiency of the asset market. When (s, M) is below and to the right of the blue line, investors prefer to be uninformed, as the costs of searching for and delegating to an informed manager outweigh the benefits of finding one. The red line is the managers' indifference condition toward learning about the risky asset. When (s, M) is above the red line, managers prefer not to pay for information, since too many managers are seeking to service investors. Below the red line, managers want to become informed.

Proposition 7 ***(Equilibrium for asset managers)***
The managers' condition is hump-shaped because of crowding out of information.

Note that sD is a concave function in s. When the number of searching investors increases from zero, the number of informed managers also increases from zero, since managers are encouraged to earn the fees paid by searching investors. M depends on both s and $D(s)$, which is a decreasing function of s (as shown in Proposition 4). Initially, the increase in s dominates the decrease in $D(s)$. However, after a point, the decrease in $D(s)$ dominates the increase in s, hence the hump-shaped form of M. After a certain threshold, the fees a manager gets decrease with the number of delegating investors. This is because active investment increases market efficiency and reduces the value of asset management services. Hence, when so many investors have searched and delegated their portfolios that the reduction in the benefit of acquiring information dominates (i.e., the reduction in $D(s)$ dominates), additional search and delegation decreases the number of informed managers.

Theorem 1 ***(Informed investing outperforms uninformed investing)***
In a general equilibrium for assets and asset management

1. *Informed asset managers outperform uninformed investing (before and after fees).*
$$u_j^{delegate} - f_j \geq u_j^{directly}$$
2. *Holding fixed other characteristics, wealthier investors who delegate their portfolios (higher W_{0j}) earn higher expected returns (before and after fees) and pay lower percentage fees on average.*

Proof **1** *See the Appendix.*

The fact that informed asset managers outperform uninformed investors (before and after fees) comes from the fact that investors must have an incentive to incur search costs to find an asset manager and pay the asset management fees. Thus, investors who have incurred the search cost can effectively predict manager performance. These results may explain why hedge funds, for example, deliver larger outperformance (see the evidence in section 5)).

Wealth Thresholds. $W_{0j}^{Particip}$ is the level of wealth that makes an agent indifferent between being a non-stockholder and a passive stockholder of any risky asset. It is given by $W_{2j|\sigma_{s,ji}^{-2}=0} = rW_{0j}^{Particip}$. This can be solved explicitly from the budget constraint, as shown in the Appendix:
$$W_{0j}^{Particip} = \frac{2r\rho F}{\left[\left(\sigma_z^{-2} + s^2\sigma_x^{-2}\right) D\right] - 1} \tag{16}$$

where I plugged in $\rho(W_{0j}) = \frac{\rho}{W_{0j}}$, and D is defined in equation (13). The wealth threshold for participating, $W_{0j}^{Particip}$, increases with absolute risk-aversion ρ, and = the fixed entry fee, F.

$W_{0j}^{NotActive}$ is the level of wealth that makes an agent indifferent between delegating to an informed manager and not participating at all, $W_{2j|\sigma_{s,j}^{-2}=\sigma_{s,m}^{-2}} = rW_{0j}^{NotActive}$. This is given by two equations. The first represents the fact that the benefit of delegating has to equal the opportunity cost of delegating. The second is the manager's optimal precision level, $\sigma_{s,m}^{-2} = \frac{sD}{4c_1}$. Combining the two yields an implicit equation in $\sigma_{s,m}^{-2}$:

$$W_{2j|\sigma_{s,j}^{-2}=\sigma_{s,m}^{-2}} = rW_{0j}^{NotActive} \tag{17}$$

Finally, W_0j^{Search} is the level of wealth that makes an agent indifferent between delegating to an informed manager and participating passively without any private information, $W_{2j|\sigma_{s,j}^{-2}=\sigma_{s,m}^{-2}} = W_{2j|\sigma_{s,j}^{-2}=0}$. This can be deduced from the condition of the marginally delegating investor, who is exactly indifferent between delegating his/her portfolio and investing on his/her own, $U_j^{delegate} - \omega - f_j = U_j^{directly}$.

$$W_{0,j}^{Search} = \frac{16\omega\rho c_0}{(sD - 4c_1)D} \tag{18}$$

Note that $\partial D/\partial s < 0$, $\partial sD/\partial s > 0$ then < 0, $\partial sD^2/\partial s > 0$ then < 0, and $\partial s^2 D/\partial s > 0$. We also have that $\partial(sD - 4c_1)D/\partial s > 0$, which means $\partial W_{0,j}^{Search}/\partial s < 0$, which is natural. And $\partial W_{0,j}^{Particip}/\partial s < 0$.

<u>**Theorem**</u> **2** ***(Two categories of equilibria depending on parameters)***
There are two categories of equilibria, as shown in Figure (5).

1. *Equilibrium (a) displays three types of investors: non-stockholders, direct (uninformed) investors, and delegating (informed) investors, as shown in Figure (5)(a). The condition for this equilibrium category is given by*
$$0 < W_{0j}^{Particip} < W_{0j}^{NotActive} < W_{0j}^{Search} < W_{0j}^{Max} + \infty \tag{19}$$
2. *Equilibrium (b) displays only two types of investors: non-stockholders and delegating (informed) investors, as shown in Figure (5)(b). The condition for this equilibrium category is given by*
$$0 < W_{0j}^{Search} < W_{0j}^{NotActive} < W_{0j}^{Particip} < W_{0j}^{Max} + \infty \tag{20}$$

Proof **2** *See the Appendix.*

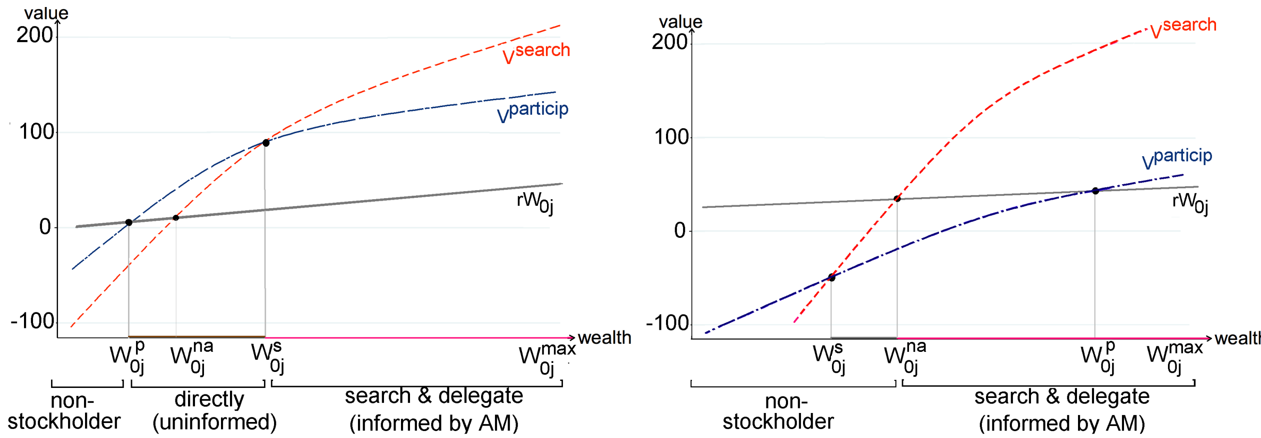
For the purpose of this paper, I choose the parameters of the model in such a way as to study only the first equilibrium category. This second equilibrium is not the focus of this paper because it does not reflect the fact that in reality, some investors acquire stocks independently without learning any private information about them.

In the first equilibrium, poor investors with wealth lower than $W_{0j}^{Particip}$ do not trade at all in the risky stock. Middle-class investors with wealth higher than $W_{0j}^{Particip}$ but lower than W_{0j}^{Search} trade on their own without acquiring any information about any risky asset. These uninformed traders

Figure 5: **Two Configurations of Equilibria by Investor Initial Wealth**

(a) Equilibrium with three investor types

(b) Equilibrium with two investor types



Legend: The y-axis represents value; the x-axis represents initial wealth. rW_{0j} = the value of not participating in the stock market, V^{particip} = the value of participating uninformedly, and V^{search} = the value of searching for and delegating to an informed manager. Equilibrium configuration (a) has non-stockholders (poor) and uninformed (indexers) and informed (delegating) investors. Equilibrium configuration (b) has only non-stockholders (poor) and informed (delegating) investors. The equilibrium configuration depends on the magnitude of the fixed costs.

are equivalent to indexers in the sense that they buy stocks without learning any private information about the stocks in the index. Lastly, relatively richer investors, whose wealth exceeds W_{0j}^{Search}, delegate their portfolios to informed professional asset managers. These wealthy investors end up being informed through their managers and invest actively.

4 Comparative Statics: Improvements in Financial Technology

In this section, I perform several comparative statics. The exercise assumes innovations in financial technology lower (1) the cost of stock market participation, (2) the cost of information acquisition, and (3) the cost of finding an informed asset manager one at a time. All proofs are in the Appendix.

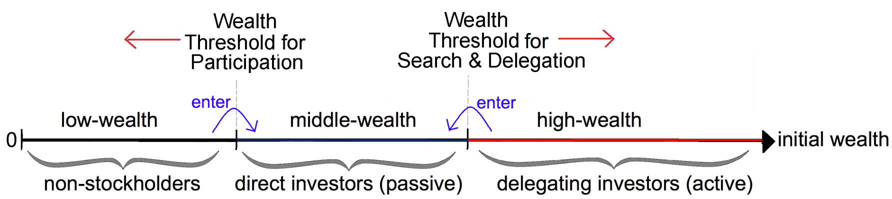
Theorem 3 ***(Lower participation costs improve participation, but hurt efficiency)***
As the fixed costs of stock market participation fall,

1. *Stock market efficiency falls, and prices become less informative (i.e. noise increases).*
$$\frac{ds\downarrow}{dF\downarrow} > 0$$
2. *The overall stock market participation rate increases.*
$$\frac{dt\uparrow}{dF\downarrow} < 0$$
3. *The equity premium and the variance of returns fall.*
$$\frac{dEP\downarrow}{dk\downarrow} > 0; \qquad \frac{dVar\downarrow}{dk\downarrow} > 0$$

4. The number of asset managers grows, and asset management fees increase.

$$\frac{dM \uparrow}{dF \downarrow} < 0; \qquad \frac{df_j \uparrow}{dF \downarrow} < 0$$

Figure 6: Effects of Lower Participation Costs, F



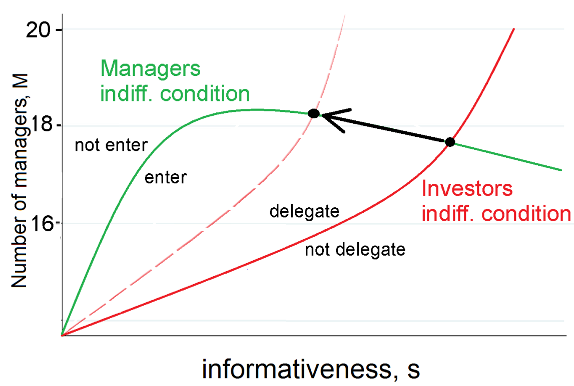
***Proof* 3** *See the Appendix.*

The intuition is shown in Figure (6). As more investors enter the stock market, the wealth threshold for participation shifts to the left. But now, each participating investor holds a smaller portfolio. The equity premium falls to clear the asset market. The market inefficiency grows, so more managers enter and they now charge higher fees.

Hence, for the marginally delegating investor, his/her value of delegating to a manager falls, as this investor now holds fewer assets in his/her portfolio on average. The marginally delegating investor no longer delegates but prefers to invest independently without any private information. Thus, the wealth threshold for search and delegation moves to the right.

So, lower participation costs lead to more participation, but lower information, and more managers who charge higher fees.

Figure 7: **Search & delegating investors' indifference curve shifts left**



Theorem 4 ***(Lower information costs hurt participation, but improve efficiency)***
When information processing and acquisition costs fall,

1. Stock market efficiency rises, and prices become more informative (i.e. the noise decreases).

$$\frac{ds \uparrow}{dk \downarrow} < 0$$

2. *The overall stock market participation rate decreases.*

$$\frac{dt \downarrow}{dk \downarrow} > 0$$

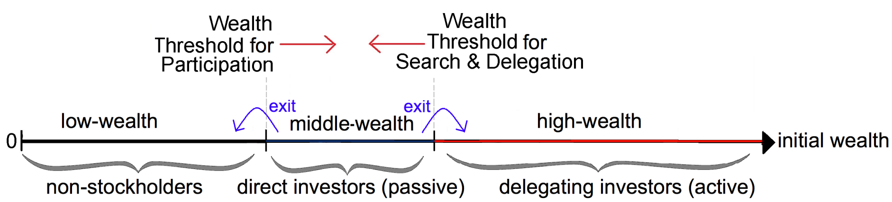
3. *The equity premium and the variance of returns rise.*

$$\frac{dEP \uparrow}{dk \downarrow} < 0; \qquad \frac{dVar \uparrow}{dk \downarrow} < 0$$

4. *The number of active managers increases, and asset management fees decrease.*

$$\frac{dM \uparrow}{dk \downarrow} < 0; \qquad \frac{df_j \downarrow}{dk \downarrow} > 0$$

Figure 8: Effects of Lower Information Acquisition Costs, κ



***Proof* 4** *See the Appendix.*

The intuition is shown in Figure (8). When information costs fall, managers' fees fall. This encourages more investors to delegate to informed managers. So, the wealth threshold for searching for and delegating to a manager, moves to the left, and the overall information in the economy, s, increases. Market inefficiency is now lower. A lower information cost moves managers' indifference curve out and up. This leads to a larger number of asset managers and more informed wealthy investors in equilibrium.

But relatively low-wealth investors exit the stock market altogether (t decreases) because they no longer find it profitable to participate against a larger mass of high-wealth investors, who are now benefiting from increased information. They are driving the price up, so the marginal participating investor exits the stock-market. Thus, the wealth threshold for participation moves to the right, in the opposite direction.

So, lower information costs lead to less participation, but higher information, and more managers who charge lower fees.

Theorem 5 ***(Lower search costs hurt participation, improve and consolidate efficiency)*** *When investors' cost of searching for an informed asset manager falls,*

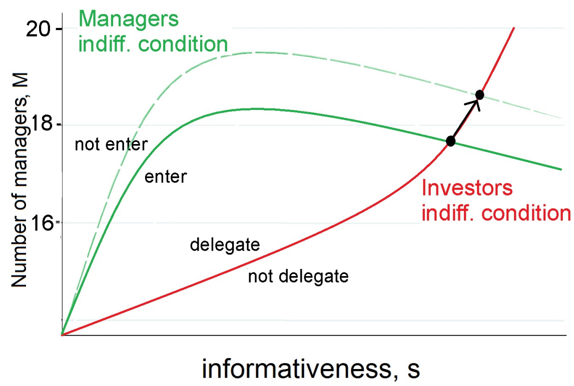
1. *Stock market efficiency rises, and prices become more informative (i.e. noise decreases).*

$$\frac{ds \uparrow}{d\omega \downarrow} < 0$$

2. *The overall stock market participation rate falls.*

$$\frac{dt \downarrow}{d\omega \downarrow} > 0$$

Figure 9: **Managers' indifference curve shifts up**



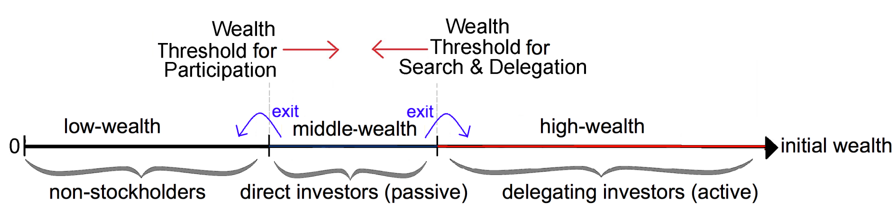
3. *The equity premium and the variance of returns rise.*

$$\frac{dEP \uparrow}{dk \downarrow} < 0; \qquad \frac{dVar \uparrow}{dk \downarrow} < 0$$

4. *The number of asset managers is a concave function of search costs (i.e., the number of active managers falls to 0 at the limit).*

$$\frac{dM \uparrow}{d\omega \downarrow} < 0 \textit{ for small values of } s, \textit{ and } \frac{dM \downarrow}{d\omega \downarrow} > 0 \textit{ for large values of } s$$

Figure 10: Effects of Lower Search Costs, ω



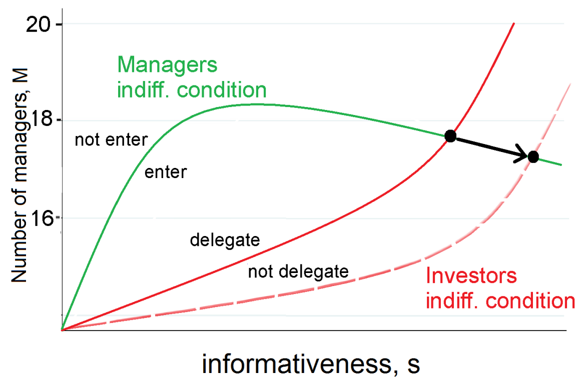
Proof **5** *See the Appendix.*

The intuition is shown in Figure (10). When search costs fall, managers' fees fall. This encourages more investors to delegate to informed managers. So, the wealth threshold for finding an informed manager, moves to the left, and the overall information in the economy, s, increases. We have shown before that as s increases, the asset management industry starts to consolidate (M falls). This is because the market becomes so efficient, that one big manager captures all the fees.

As with lower information costs, relatively low-wealth investors exit the stock market altogether (t decreases) because they no longer find it profitable to participate against a larger mass of high-wealth investors. Thus, the wealth threshold for participation moves to the right, in the opposite direction.

So, lower search costs lead to less participation, but higher information, and fewer managers in the limit who charge lower fees.

Figure 11: **Search & delegating investors' indifference curve shifts out (right)**



4.1 Overall Outcome for the Final Wealth Distribution

In this section, I do a basic simulation of the model. I start with a normally distributed initial wealth distribution and plot the intermediary and terminal wealth distributions that result from the model when the search and information effects dominate the participation effect. That is, I plot a counterfactual of the US capital wealth distribution in the last 20 years where, in the early 2000s, wealth was normally distributed. Figure (12) shows that new information technologies skew the distribution to the right, generating fat right tails, as observed in the data.

Figure 12: **Overall Effect of Innovations in Financial Technology On The Final Wealth Distribution**

The initial wealth distribution (in blue) is normally distributed. The intermediary distribution (in red) and the final wealth distribution (in pink) are skewed and exhibit long and fat right tails.

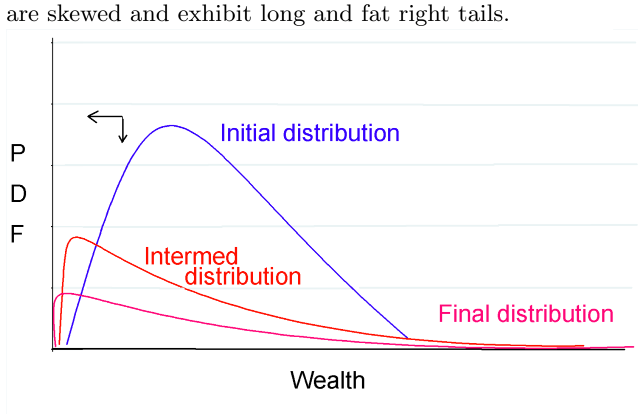


Figure (12) shows that, far from creating a level playing field where more readily available information simply leads to greater market efficiency, the information revolution has had the opposite impact. It can create hard-to-access opportunities for long-term alpha generation for those players with the scale and resources to take advantage of it. These predictions are consistent with recent empirical evidence from the United States, as I will show in Section 5.

The model generates a thick right tail on the capital income distribution, as is present in the US data, which most economic models have a hard time matching. For example, Bewley-Aiyagari economies, which focus on precautionary savings as an optimal response to stochastic earnings, cannot produce wealth distributions with substantially thicker right tails (larger top shares) than the labor earnings distribution that has been fed into the model. This is explicitly noted by DeNardi et al. (2016) and Carroll et al. (2017), and by Hubmer et al. (2016), who conclude that *"the wealth distribution inherits not only the Pareto tail of the earnings distribution, but also its Pareto coefficient. Because earnings are considerably less concentrated than wealth, the resulting tail in wealth is too thin to match the data."* Other papers add heterogeneous lifespans in overlapping generations models (assuming death rates independent of age) to amplify wealth inequality, but these papers imply that a significant fraction of agents enjoy counterfactually long lifespans. Gabaix et al. (2016) and Benhabib et al. (2017) argue that return heterogeneity is the most plausible ingredient to obtain a Pareto tail for the capital income distribution.

In the United States, wealth is concentrated at the very top. Data from the U.S. Census show that between 2000 and 2011, wealth increased for those in the top two quintiles and decreased for those in the bottom three (see Table (1)). Other statistics from the Survey of Consumer Finance and from Saez and Zucman (2016) show that in 2013, the top 1% held 30% of total wealth, and the top 10% of families held 76% of the wealth, while the bottom 50% of families held 1%. In 2016, the top 1% held 38.6%, and the top 10% of families held 90% of the wealth, while the bottom 50% of families held 0.5%. And while the majority of net-worth holdings is in real estate, a significant portion is also held in the stock market (either directly or indirectly).

Table 1: **Changes in net worth for US households between 2000 and 2011**

Quintile	Median Net Worth (2000)	Change by 2011
WQ1	−$905	−566%
WQ2	$14,319	−49%
WQ3	$73,911	−7%
WQ4	$187,552	+10%
WQ5	$569,375	+11%

Source: US Census.

4.2 Generalizations

The results of the model are robust to a number of generalizations and to other sources of heterogeneity than wealth and risk aversion. The only requirement is that the dimensions that differentiate agents create heterogeneity in their demand for stocks. For example, differences in information costs, differences in age and lifespan, and differences in exposure to background risk all affect the demand for risky assets relative to bonds and generate similar results.

It is important to clarify differences between CARA and DARA preferences (which include CRRA). With CARA utility, wealth plays no role: It is irrelevant to the decisions to participate or to acquire information (at the intensive and extensive margins). However, wealth is highly relevant empirically. Lusardi et al. (2017) show that the decision to participate is significantly correlated with financial wealth. The probability of participation and the proportion of wealth invested in stocks increase with wealth, mean income, and education but decrease with the variance of income.

Thus, it is important to have a setting where financial wealth matters. CRRA preferences give relevance to wealth. But because there is no closed-form solution for equilibrium in a CRRA setting (because the price is no longer a linear function of the payoff and supply), I resort to a CARA approximation of CRRA preferences, using a strictly decreasing absolute risk aversion.

The effects of lower search and information costs are obtained not only in my chosen setting but also under CARA preferences. All that matters is the presence of a margin for participation and the coexistence of three groups of stockholders: non-stockholders, indexers, and (delegating) informed investors. Falling search and information costs benefit wealthy investors, who acquire more stocks, but harm direct investors who invest uninformedly, who now face a less advantageous risk-return tradeoff.

The major difference under CARA preferences is that the fixed entry cost no longer generates an information effect. The demand for information is unrelated to the expected supply of shares and to the market risk tolerance and thus to the level of participation in the stock market. This means that the variance of returns always falls with lower entry costs.

With regards to preferences for early or late resolution of uncertainty, the results in this paper are obtained by construction because of the mean-variance preference structure. As search and information technologies improve, investors learn more about the stochastic payoffs earlier. As the risk moves from the consumption to the trading period, there are larger gains from trade in earlier periods. If traders were allowed to trade before the private signals were observed, then the ex-ante utility would be linear with wealth, and the traders would effectively be risk-neutral. The risk premium would equal zero.

Thus, the results of this paper are obtained by construction. Lower noise (i.e., better information) does not attract investors in the stock market in this model because better information reduces the gains from trade in the second period. Moreover, better information can also reduce the risk premium in the first period.

The results are also obtained in a dynamic version where the stock return consists of both the next period's dividend and the stock's resale price. The difficulty lies in the variance of returns. When information technologies improve, current asset prices reflect future earnings and prices more closely, thereby increasing price informativeness and reducing the return variance, as in the static model. However, the volatility of future prices also rises because future prices reflect dividends even better and further into the future. But because future prices and earnings are discounted at a risk-free rate, the former effect dominates the latter.

In the words of Campbell et al. (2001), "*better information about future cash-flows increases stock price volatility, but reduces the volatility of the stock return because news arrives earlier, at a time when the cash-flows in question are more heavily discounted*".

Lastly, the functional forms of the entry, search and information acquisition costs do not make a qualitative difference to the results. Their functional forms were chosen for mathematical tractability and simplicity, but one could also solve the model with more general cost functions for information or search. The implications would not change.

5 Suggestive Evidence For Proposed Mechanism

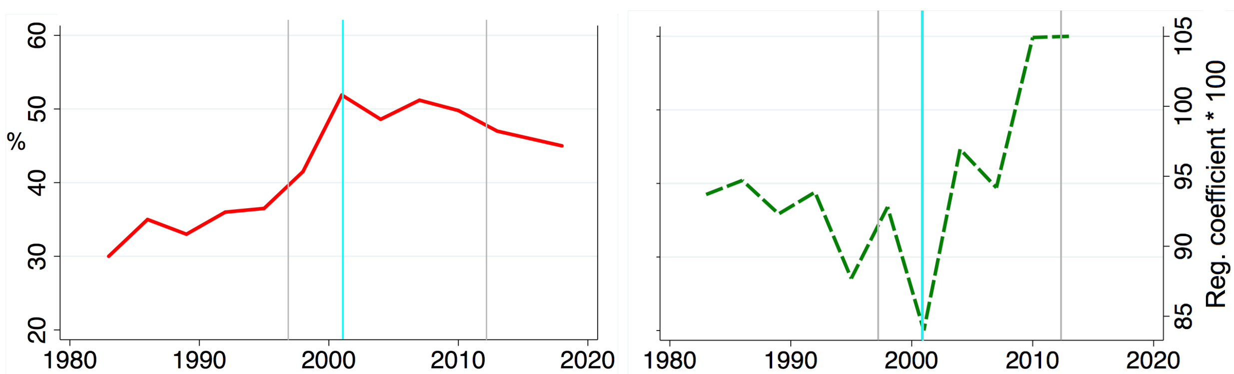
In this section, I will offer some suggestive evidence of the model's predictions. I do not claim a causal effect, because I do not perform a causal testing of the model's predictions using micro data. The macro data shown are just indicative evidence of the model's mechanism.

The data seem to suggest that the early 2000s were a time of a technological U-turn in financial markets. It seems that the effect of a decline in participation costs increased the participation rate and decreased price informativeness before 2001. The year 2001 coincides with the emergence of electronic trading. On the other hand, the data also suggest that access to good information technologies has become more important since 2001.

Figure 13: **US Stock Market Participation and Price Informativeness Over Time**

a) Participation

b) Price informativeness



Legend: Participation (weighted) is from SCF and includes direct and indirect holdings. Bai et al. (2016) compute stock price informativeness by running cross-sectional regressions of future earnings on current market prices.

The model suggests that as participation costs decrease, the participation rate increases due to a boom in passive investing opportunities. As a consequence, stock prices become less informative. This is what we see in the data plotted in Figure (13) prior to 2001.

In the model, improvements in data technologies make passive investing a less attractive option relative to active investing. This increases stock price informativeness but decreases participation. This is observable in the data plotted in Figure (13) after 2001.

Predictions on other macro-financial variables, such as returns, the equity premium, inequality, and asset manager size and concentration, provide additional support for the economic mechanism I propose. I discuss these predictions and the evidence below.

Implication 1 ***(Returns Increase With Wealth from Theorem 1.(ii))***

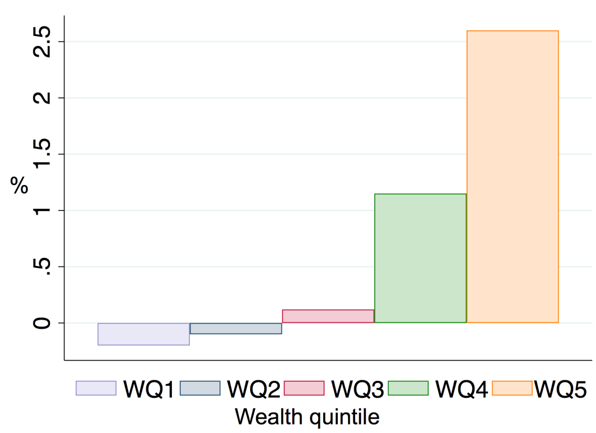
Risk-adjusted returns increase with wealth.

A result of endogenous information acquisition in a CRRA setting is that wealthier investors attain higher risk-adjusted returns (see Theorem 1(ii)). This is consistent with the empirical household finance literature (Kacperczyk et al. (2018) for the United States, Fagereng et al. (2016) and Di Maggio et al. (2018)) for Scandinavia, and Campbell et al. (2018) for India).

Generating capital returns that increase with wealth is not a straightforward modeling result. Chiappori and Paiella (2011) show that relative risk-aversion is constant. So, in the data, it is not the case that as risk-tolerant wealthy investors take on higher-risk strategies, they achieve higher returns on wealth. In my model, returns increasing with wealth arises through an absolute risk-aversion channel in the context of information acquisition. This happens because information has increasing returns to scale for wealthy investors, as they have more capital invested in the stock market anyway. The lower the absolute risk-aversion, the higher the incentive to find a manager with more precise information, and thus, the larger the trading payoffs.

Unfortunately, portfolio level data for the US are not easily available, but most likely, the pattern in the distribution of Sharpe ratios in the US is similar – if not starker – than the one in the Norwegian population. Figure (14) plots the risk-adjusted returns (i.e., Sharpe ratios) for the five different wealth quintiles of the Norwegian population. The Sharpe ratios for the bottom two quintiles are negative. The third wealth quintile achieves a small, positive Sharpe ratio less than 0.5. The fourth and fifth wealth quintiles achieve much larger risk-adjusted returns of 1.2 and 2.6, respectively.

Figure 14: **Wealthier Investors Achieve Higher Risk-Adjusted Returns**



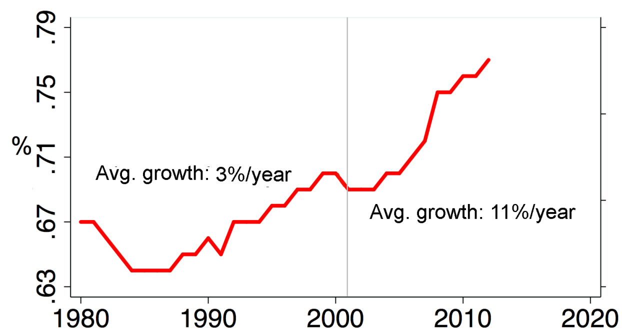
Source: Fagereng et al. (2016) compute Sharpe ratios for all Norwegian individuals.

Ideally, one would want to see a time series of investors' Sharpe ratios by wealth quintile. My model suggests that the Sharpe ratio distribution has become more unequal in the last 20 years.

Implication 2 ***(Welfare and Inequality from Theorems 3, 4, and 5)***
Capital income inequality decelerates with the participation effect (i.e., with higher participation which increases access to the risk premium) and accelerates with the information and search effects (i.e., with lower participation which decreases access to the risk premium).

The data suggest that prior to 2001, there was a large increase in participation. In the model, the participation/risk-sharing effect allows more investors passive access to the equity premium. Thus, in the data, we should observe a deceleration of capital income inequality before 2001. On the other hand, after 2001, the decrease in participation coupled with the dramatic increase in stock price informativeness suggests that the information effect was more important. Thus, after 2001, the data should show an amplification of inequality with digital innovations.

Figure 15: **Capital Wealth Inequality Pre- and Post-2001**



Legend: Capital wealth inequality is measured as the difference between the capital share of the top 10% and that of the bottom 90%. Source: Saez and Zucman (2016).

Indeed, the data plotted in Figure (15) shows that between 1980 and 2001, when the participation effect dominated the information and search effects, capital wealth inequality increased little, from 67.1 to 69.2 between (i.e., a 3.1% increase). After 2001, when the data suggest that the information effect dominated the participation effect, inequality rose from 69.2 to 77.2 (i.e., an 11.5% increase).

It is important to note that there are other effects driving up inequality both before and after 2001: taxes, regulation, and antitrust policy. My model does not capture all of these margins.

I only capture a small effect of the rise in inequality due to the tradeoff between participation and information. This is similar to evidence by Lei (2019), who finds that information effects alone account for only 60% of the total increase in inequality after 1980. My model generates more inequality than that of Lei (2019) by definition because the general equilibrium effects are more complex and the existence of a margin for participation amplifies inequality.

One could carefully calibrate the model to deduce how much of the recent increase in inequality the model can explain. Moreover, one could extend the model with oligopolistic markets for asset management. This would further amplify capital income inequality.

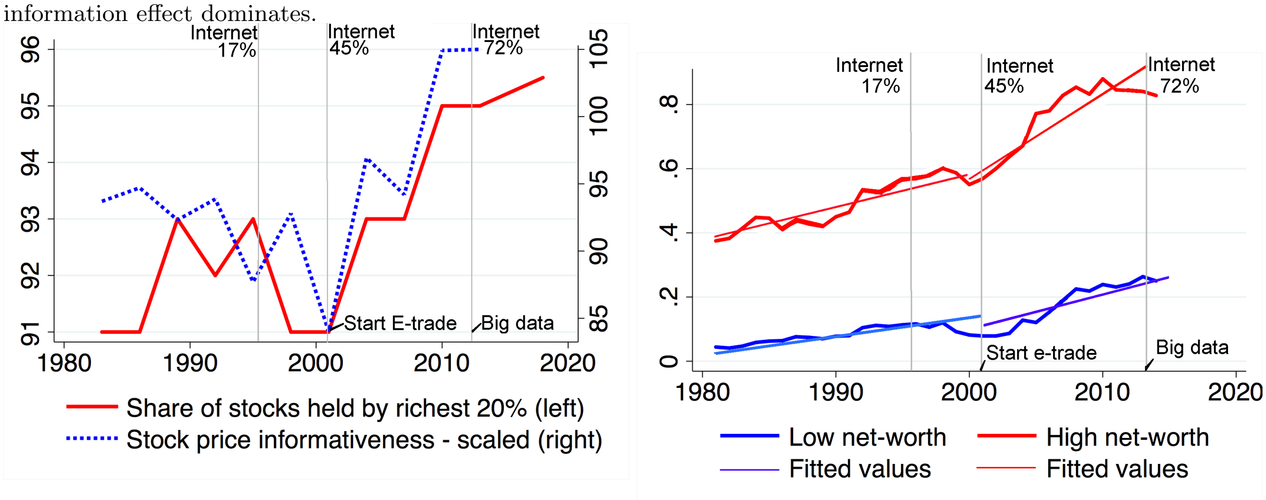
Implication 3 ***(Price Informativeness/Market Efficiency from Theorems 3, 4, and 5)*** *Stock price informativeness falls when the participation effect dominates and rises when the search and information effects dominate. Moreover, in the cross-section, the price informativeness of stocks held by high-wealth investors should rise by more than that of stocks held by less-wealthy investors.*

The model implies that when the participation effect dominates, the informativeness of stock prices falls. On the other hand, when the search and information effects dominate, price informativeness rises. Moreover, in the cross-section, because the wealthy have access to better information technology through privately informed asset managersn, the price informativeness of the stocks they hold should be rising relative to the price informativeness of stocks held by lower-wealth investors.

Indeed, this prediction seems to hold in the data, as shown in Figure (16). The left hand-size panel shows the U-shaped pattern in price informativeness over time. It is negatively correlated with the share of stocks held by the wealthiest 20%. This means that it is indeed the wealthy who are gaining access to most of the private information in financial markets.

Figure 16: **Aggregate and Cross-Sectional Dynamics of Price Informativeness**

Left: U-shaped price informativeness. Right: Price informativeness diverges for the rich and the poor when the information effect dominates.



The right-hand-side panel shows the price informativeness of stocks held by high-net-worth and low-net-worth investors, which diverges after 2001. This observation elicits an interesting research question in itself: What stocks do wealthy investors hold? Begenau et al. (2018) argues that wealthy investors hold growth stocks, whose prices are more informative about fundamentals, because the wealthy do more private information acquisition.

Implication 4 ***(The Equity Premium from Theorems 3, 4, and 5)***
The equity premium falls when the participation effect dominates and rises wheb the search and information effects dominate.

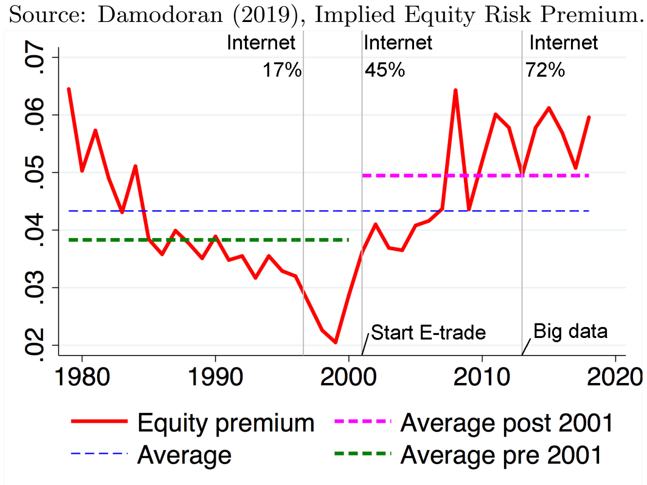
The equity risk premium is the price of risk in equity markets, and it is a key input in estimating the costs of equity and capital in both corporate finance and valuation. The model implies a falling equity premium when the participation effect dominates and a rising equity premium when the information effect dominates.

At the one end of the spectrum, a fall in the entry cost of holding aggregate information constant (i.e., s is constant) results in a falling equity premium. The participation effect operates alone. As participation rises, the equity premium and the variance of returns fall. At the other end of the spectrum, better information technologies result in a rising equity premium. This is because some passive stockholders become active (and the price rises), but some passive stockholders exit the market altogether (and the price falls). When many passive stockholders exit the stock market, the equity premium rises to compensate the investors for lower risk-sharing in the market.

Note that the estimation of the equity risk premium is not so straightforward to begin with. In the standard approach, historical returns are used. The expected risk-premium is calculated as the difference in annual returns on stocks versus bonds over a long period. There are many limitations to this approach (see Damodoran, 2019), even in markets like the United States, which have long periods of historical data available. It is a complete failure in emerging markets, where historical data tend to be limited and volatile. The main limitation of this approach is that it generates backwards-looking equity premia that lean heavily on assumptions of mean reversion and past data. Thus, in the Appendix, besides the historical premium, I also plot the implied risk premium from various models of valuation, such as a free cash flow to equity model (FCFE) and a dividend discount model (DDM). The U-shaped pattern of the equity premium, whether historical or implied, is robust to all these different ways of measuring the premium.

Figure 17: **The equity premium fell before 2001, then rose with the information revolution**

Source: Damodoran (2019), Implied Equity Risk Premium.



The theoretical implication of the model finds support in the data. Prior to 2001, the equity premium fell from over 8% in 1982 to 0% in 2001, as shown in Figure (17). The fall in the equity premium is simultaneous with the rise in stock-market participation in the US. However, after the start of the new millennium – which is when electronic trading and other financial information technologies emerged – the equity premium starting rising. Note that the equity premium has always been positive and has not once in the last 40 years become negative. This always implies that when some investors lose access to the equity premium, they will be worse off.

Implication 5 ***Manager Performance from Theorem 1. (i)***
Active investing earns higher returns (before and after fees) than passive investing.

The "old consensus" in the finance literature was that the average fund manager had no skill and that managers underperformed by an amount equal to their fees. In the last few years, a "new consensus" has emerged. Recent empirical evidence suggests that the average alpha after fees is not negative but actually slightly positive (Berk and Binsbergen, 2015). Moreover, a growing body of literature shows that evidence for the average asset manager hides significant cross-sectional variation in manager skill among mutual funds, hedge funds, private equity, venture capital funds, etc. Theorem 1 shows that there should be significant cross-sectional differences in returns between and within investors and managers.

Evidence on the risk-adjusted returns attained by hedge funds is provided by Preqin and AIMA (2018), Kosowski et al. (2007), Fung et al. (2008), and Jagannathan et al. (2010); on private equity and venture capital by Kaplan and Schoar (2005); and on single and multiple family-owned offices by UBS Surveys. Data from Preqin and AIMA (2018) show that hedge funds have produced more consistent and steadier returns than equities or bonds over both the short term and the long term, as shown in Table 2. Risk-adjusted returns, represented by the Sharpe ratio, reflect the volatility of the returns as well as the returns themselves. The higher the ratio, the better the risk-adjusted returns. The risk-adjusted return as measured by the Sharpe ratio is calculated by subtracting the risk-free rate (typically the return on US treasury securities) from the fund or index performance (returns, net of fees) and dividing this by the fund or index's volatility. The empirical analysis is based on the returns of more than 2,300 individual hedge funds that report to Preqin's All-Strategies Hedge Fund Index, an equal-weighted benchmark. Moreover, according to my own analysis of the data, about 32% of all hedge funds produced double-digit returns in 2017, up from about 23% in 2016. Thus, this hypothesis is verified, and indeed, active managers beat stock and bond indices on a risk-adjusted basis at short- and long-term horizons.

Table 2: **Hedge funds beat stock and bond indices on a risk-adjusted basis**

Legend: Sharpe ratios for hedge fund managers, the S&P 500 equity index, and the Bloomberg-Barclays global bond index. Source: Preqin and AIMA (2018).

Horizon	Hedge funds	S&P 500	BB global bonds
1-year	0.65	0.40	0.18
3-year	1.37	0.98	0.09
5-year	1.58	1.46	−0.24
10-year	0.73	0.41	0.13

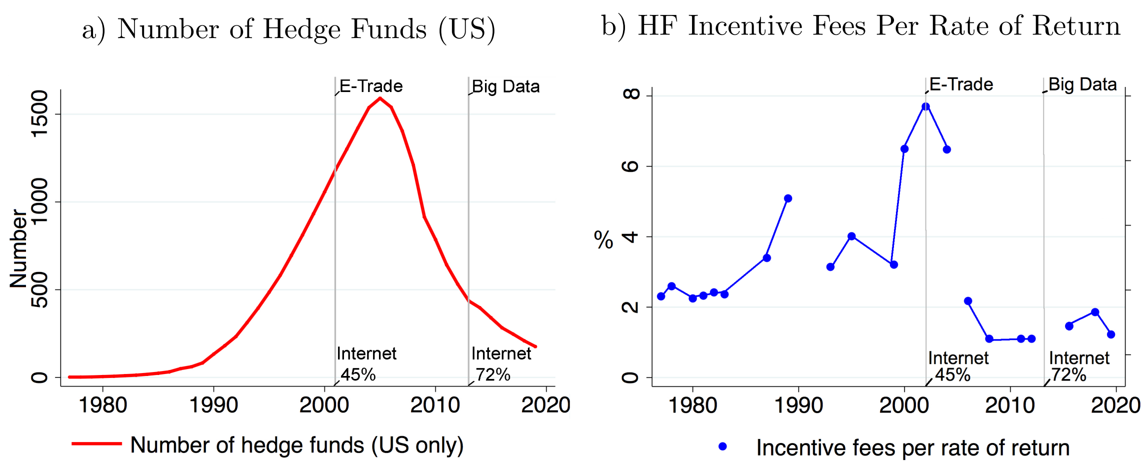
There is also evidence that hedge funds outperform even net of fees. Kosowski et al. (2007) (p. 2551) conclude that "a sizeable minority of managers pick stocks well enough to more than cover their costs." In the model, this outperformance after fees is expected as compensation for investors' search costs, but it is still puzzling in the light of the "old consensus" that all managers deliver zero outperformance after fees (or even negative performance after fees). Kosowski et al. (2007) add that "top hedge fund performance cannot be explained by luck, and hedge fund performance persists at annual horizons. [...] Our results are robust and neither confined to small funds nor driven by incubation bias, backhill bias, or serial correlation."

Data on the excess returns of family-owned offices (FO) are less systematic because these entities are not regulated and do not have to report their financial activities to regulators. However, various market surveys of their activities suggest that FOs are active asset management companies and they make annual returns of between 17% and 35%, which is much higher than any passive index (see the Global Family Office Report by UBS and Campden Wealth).

Implication 6 ***(Hedge Funds Number and Fees from Theorems 3, 4, and 5)***
The model predicts that a fall in the participation cost increases the number and the fees of the active investing industry. A fall in information costs increase the number of managers, but decreases fund fees and expenses. A fall in the search costs leads to a decrease in both the number and fees charged by active managers.

Using data from Lipper, in Figure (18), I plot the number of hedge funds entering the US asset management industry every year. Indeed, prior to 2001, the number of hedge funds entering the US asset management industry was exploding. After 2001, this number tapered off and starting falling (because of either exits or mergers and acquisitions). The important takeaway is that the hedge fund industry has become more consolidated since 2001.

Figure 18: **Entry in the hedge fund industry**



Source: Lipper TASS Hedge Fund Database.

While my model does not assume market power in the asset management industry in order to keep the solution tractable, it predicts that, as information and search costs fall, the number of informed managers falls. Perhaps a useful extension of my model would be to assume this market power in the asset management industry. We already know from Kacperczyk et al. (2017) that large investors with market power trade strategically in order to obscure their private information. This suggests that not only would capital income inequality be amplified, but market efficiency would also fall, and prices would reflect less information than in perfectly competitive markets.

6 Policy Implications

Innovations often take on lives of their own, independent of their innovators' wishes and intentions, and although they may be created in good faith, the old adage is that "the road to hell is paved with good intentions." Albert Einstein is one inventor who came to regret his inventions, or rather, dislike their use. He initially urged Roosevelt to support research of what would eventually become the most destructive weapon ever constructed by mankind. Years later, he regretted this, reportedly saying, "Had I known that the Germans would not succeed in producing an atomic bomb, I would have never lifted a finger." With more innovations in the present than ever before, it is important to consider the impact of these technological advances on the wider society and carefully think about their policy implications.

The results of my model crucially depend on the coexistence of a margin for participation and a margin for delegation to active fund managers. Policymakers should target these two margins to ensure access to the equity premium while ensuring equitable access to the risk premium as well.

One direct policy implication is that policymakers should try to reduce the fixed costs of stock market participation and facilitate universal access to the internet, phones, and computers. Clearly, the fixed costs of stock-market participation (i.e., time and money spent understanding how to start trading, as well as the fixed costs of installing e-trading applications and accessing the internet and web applications that allow small investors to trade) have been falling over the last 40 years. They reached their lowest point with the start of e-trading technologies. Still, while e-trading allows investors to download an app or just trade stocks through their internet browsers, there are still opportunity costs of doing so, such as the costs of dealing with tax forms for investing activities, of understanding different asset classes, etc. There is only so much a policymaker can do to decrease these costs. There is evidence, however, that computer- and internet-using households raised their stock-market participation rates substantially more than non-computer-using households after 2000, holding fixed characteristics such as access to 401Ks (see Bogan (2008)). The increased probability of participation was equivalent to having over $27,000 in additional household income (or over two more years of education). A conclusion of this study is that policymakers should ensure greater access to computers and the internet.

Another direct policy implication is related to improving the financial education of US households through academic education, but also money management workshops, ads, etc. Lusardi et al. (2017) show that investors who have low financial literacy are significantly less likely to invest in stocks. This non-participation phenomenon of less sophisticated/less wealthy/less cultured households is an important part of the potential solution to the equity premium puzzle. Mankiw and Zeldes (1991) were among the first to make this argument. Vissing-Jorgensen (2002) continued to stress the importance of non-participation. And limited stock-market participation matters not only for capital income inequality, but also for other macro-financial effects. For example, limited market participation can amplify the effect of liquidity trading relative to full participation. Under certain circumstances, with limited participation, arbitrarily small aggregate liquidity shocks can cause significant price volatility (see Allen and Gale (1994)). Limited market participation also dampens the effects of monetary policy and makes markets more volatile (see Morelli (2019)). Thus, improving the financial education of less sophisticated households in order to encourage their participation in the stock market is important for a policymaker who cares not only about equality but also about financial stability.

Policymakers should also think carefully about designing policies that not only provide information about stocks and mutual funds but also diminish informational asymmetries between sophisticated and less sophisticated market players. King and Leape (1987) reported that more than a third of US households did not own stocks or mutual funds in 1987 because they did not know enough about them.

Financial education reduces the costs of information acquisition, but it is not clear whether it also reduces asymmetries of information between wealthy and less-wealthy investors. Since the emergence of electronic trading in 2000, many major US financial services firms have developed a sizeable online customer base, while other companies have focused on providing stock information and financial analysis tools. They provide financial and investing data on stock prices, stock trends, corporate earnings, analysts' advice and ratings, etc. Retail investors, especially less wealthy ones, heavily utilize e-trading platforms. So, these firms have indeed increased the amount of investment information available, provided easier access to the market, and decreased transaction costs. The costs of e-trades are substantially lower than those of broker-assisted trades, the competitive presence of e-trade brokerage firms has driven down the cost of broker-assisted trades, and other rates and fees associated with stock purchases have declined (margin rates and service fees). Policymakers should continue to encourage these developments.

At the same time, regulation should also focus on not allowing those large/wealthy investors to take advantage of their scale and resources to extract "excessive" private information while small and less sophisticated retail investors struggle to acquire this information. Since the advent of big data and machine learning technologies, asset managers have been increasingly turning to "alternative data" sources with the aim of staying ahead of the competition, fueling superior client performance, and growing their customer base. These types of strategies have exploded in recent months, and by 2020, the industry for alternative financial data is projected to be worth $350 million, with total alternative data spending in excess of $1.7 billion. Data have become the "new oil," and they are businesses' most precious resource. Regulators should think about ways of regulating data processing, data acquisition, and data dissemination in financial markets so that everyone has equal access to it. This could be in the form of making datasets publicly available, offering public advice, or, if this is not possible, outright preventing access to some types of data. This is happening in Europe with the advent of the GDPR regulations that have recently been adopted to strengthen and standardize the protection (anonymity) of personal data. The main driver behind this regulation lies in the problematic nature of the complex information management system, which results in the difficulty of governing big data. Data need to be handled appropriately, and they need to be certified and compliant with local and national laws in respect of both privacy and security management.

This paper predicts that an increase in information need not result in greater economic welfare because information benefits the rich and hurts the poor. From a competition policy perspective, influential depictions of less than perfectly competitive markets demonstrate that an increase in rivalry can enhance both competitiveness and economic welfare. In these markets, it is held that reductions in barriers to entry and exit or information barriers cannot retard market performance. In other words, a reduction in these barriers is expected either to cause a fall in market prices or at least to have no effect. This perspective has led to a competition policy "rule of thumb" that a reduction in barriers should be one of the main objectives (rather than a means) of competition policy. In this paper, I have demonstrated that consideration of the tradeoff between information and participation raises doubts about this conclusion. I have argued that reduction in information costs, even if coupled with a reduction in participation costs, can still decrease participation. Stock markets are a special kind of market in that better information technologies hurt some investors because they allow the very rich to generate lots of alpha and leave behind poorer, less sophisticated investors.

Thus, more efficient markets (i.e., more informative prices) should not necessarily be the goal of financial and securities markets regulation. I have demonstrated that there is a substantial tradeoff between information and participation. While the model lacks some institutional details for tractability, I have shown that increased information can decrease participation, further exacerbating the capital income/wealth inequality problem, and this is evident in the data. Regulation should carefully balance this tradeoff. The SEC has already imposed various regulations limiting the access of smaller investors to hedge funds. There are also regulations limiting hedge funds' ability to advertise their services (see Regulation D). What this implies is that investment in hedge funds is simply designed to cater to sophisticated and/or institutional investors. This regulation may be amplifying the information–participation tradeoff that I have exposed in this paper and actually making things worse. In the case in which hedge funds do open up to less sophisticated investors, regulation should ensure that these funds provide a high degree of product transparency to protect investors' interests.

Lastly, my model has implications for the organization of the asset management industry. In the model, the overall asset management industry faces statistically decreasing returns to scale, as a larger amount of capital with informed managers leads to more efficient markets (i.e., lower θ), which reduces manager performance. This implication is consistent with the evidence of Pastor et al. (2014). It would be easy to extend the model to have heterogeneity in asset manager size, or in asset manager sophistication in processing information. In that case, individual managers would not face decreasing returns to scale, controlling for industry size, and indeed, larger and more sophisticated managers would be better off on average because searching investors look for informed managers. Thus, larger managers would perform better, which is consistent with evidence from Ferreira et al. (2012). Meanwhile, the asset management industry's size grows when investors' search costs or managers' costs of acquiring information fall. This phenomenon is consistent with evidence from Pastor et al. (2014), Berk and Green (2004), Ľubos Pastor and Stambaugh (2012), and García and Vanden (2009). Yet, as shown above, search and information costs have different impacts on the concentration of the asset management sector. With a fixed number of managers, when investors' search costs fall, the number of managers falls, while the remaining managers grow larger. Indeed, they become so much larger that the total revenue of the industry grows. This consolidation of the asset management industry is important for regulators, particularly in the context where it is known from the theoretical work of Kacperczyk et al. (2017) that players with some market power have a large impact on prices and their informativeness.

7 Conclusion

Financial technology has been gathering lots of attention in recent years. While there is plenty of hype around the its social impact, it is not clear yet whether it can make a true impact in the lives of the most financially vulnerable people. That is because financial technologies are different from other technologies. For example, information has special economic properties, such as nonrivalry. This nonrivalry implies that production possibilities are likely to be characterized by increasing returns to scale and monopoly effects, insights that have profound implications for economic growth, capital returns, and income and wealth inequality.

Wealthy investors can afford to acquire costly private information about asset managers and stock fundamentals. Once acquired, this private information allows them to earn higher capital returns, which in turn makes them wealthier, putting them in a better position to acquire even more private information. This unique property of information implies that innovations that render private information cheaper can have unintuitive effects and externalities. These innovations can make it easier for the rich to chase and achieve high returns and pull away from less-wealthy investors, who have little access to private information. Less-wealthy, less sophisticated investors will stop trading risky assets because of their informational disadvantage. Even when they pool their information resources, they still get outcompeted by higher-wealth investors, who can pool better private information.

In future work, I would like to test my model using cross-sectional portfolio-level data. Scandinavian countries provide such data from tax-related forms. Unfortunately, data for US investors are difficult to obtain. But in principle, using portfolio-level data and information related to mobile phone and internet use; financial education; use of online banking, brokerage firms; e-trading apps; and asset management offices; one can test whether the model's predictions for the cross-section and time series hold in the data. For example, one could test whether the wealthy have been achieving higher Sharpe ratios over time and investing in riskier assets, or whether poorer investors have been retrenching from risky stocks into safer assets. I base my model on aggregate trends, but the next step would be to obtain more micro-level details about which, what and how investors trade.

The overall growth of investment resources and competition among investors with different wealth levels is generally considered a sign of a well-functioning financial market. This paper highlights how advances in financial technologies also have consequences beyond the financial market, affecting the distribution of income.

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Online Appendix

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Contents

1 One Risky Asset

Proposition 1. *The optimal portfolio is given by:* $q_j^{directly} = \frac{\hat{\mu}^U_{z,j} - rp}{\rho(W_{0j})\hat{\sigma}^{U,2}_{z,j}}$ *for traders who trade on their own as uninformed, and* $q_j^{delegate} = \frac{\hat{\mu}^I_{z,j} - rp}{\rho(W_{0j})\hat{\sigma}^{I,2}_{z,j}}$ *for traders who delegate to informed managers.*

Proof. **Step 1. Solve for each investor's optimal portfolio choice**

$$\max_{q_j} E(W_{2j}|I_j) - \frac{\rho(W_{0j})}{2} var(W_{2j}|I_j) \tag{1}$$

$$\text{s.t. } W_{2j} = rW_{0j} - F - \omega - f_j + q_j[z - rp] \tag{2}$$

$$\text{Given that: } E(W_{2j}|I_j) = rW_{0j} - F - \omega - f_j + q_j[\hat{\mu}_{zj} - rp] \tag{3}$$

$$var(W_{2j}|I_j) = q_j^2 var(z|I_j) = q_j^2 \hat{\sigma}^2_{zj} \tag{4}$$

The investors' portfolio problem can be expressed as:

$$\max_{q_j} rW_{0j} - F - \omega - f_j + q_j[\hat{\mu}_{zj} - rp] - \frac{\rho(W_{0j})}{2} q_j^2 \hat{\sigma}^2_{zj} \tag{5}$$

$$\text{FOC: } \hat{\mu}_{zj} - rp - \rho(W_{0j}) q_j \hat{\sigma}^2_{zj} = 0 \implies q_j = \frac{\hat{\mu}_{zj} - rp}{\rho(W_{0j})\hat{\sigma}^2_{zj}} \tag{6}$$

■

Step 2. Guess and verify. Guess a linear form for the price: $rp = a + bz - cx$. Bayes' Law for the investors who delegate to informed managers:

$$\hat{\sigma}^{2,I}_{zj} = var(z|s_j, p) = \left[\sigma_z^{-2} + \frac{b^2}{c^2}\sigma_x^{-2} + \sigma_{sj}^{-2}\right]^{-1} \tag{7}$$

$$\begin{aligned} \hat{\mu}^I_{zj} = E[z_j|s_j, p] &= \frac{\mu_z \sigma_z^{-2} + \frac{b}{c}\mu_x \sigma_x^{-2} + (z - \frac{cx}{b})\frac{b^2}{c^2}\sigma_x^{-2} + s_j \sigma_{sj}^{-2}}{\hat{\sigma}^2_{zj}} \\ &= \frac{\mu_z \sigma_z^{-2} + \frac{b}{c}\mu_x \sigma_x^{-2} + z\frac{b}{c}\sigma_x^{-2} - x\frac{b}{c}\sigma_x^{-2} + s_j \sigma_{sj}^{-2}}{\left[\sigma_z^{-2} + \frac{b^2}{c^2}\sigma_x^{-2} + \sigma_{sj}^{-2}\right]} \end{aligned} \tag{8}$$

For the investors who do not delegate to informed managers, but trade the risky asset, just have $\sigma_{sj}^{-2} = 0$ and s_j disappear from the equations:

$$\hat{\sigma}^{2,U}_{zj} = var(z|p) = \left[\sigma_z^{-2} + \frac{b^2}{c^2}\sigma_x^{-2}\right]^{-1} \tag{9}$$

$$\begin{aligned} \hat{\mu}^U_{zj} = E[z_j|p] &= \frac{\mu_z \sigma_z^{-2} + \frac{b}{c}\mu_x \sigma_x^{-2} + (z - \frac{cx}{b}\frac{b^2}{c^2}\sigma_x^{-2})}{\hat{\sigma}^2_{zji}} = \\ &= \frac{\mu_z \sigma_z^{-2} + \frac{b}{c}\mu_x \sigma_x^{-2} + z\frac{b^2}{c^2}\sigma_x^{-2} - x\frac{b}{c}\sigma_x^{-2}}{\left[\sigma_z^{-2} + \frac{b^2}{c^2}\sigma_x^{-2}\right]} \end{aligned} \tag{10}$$

Define objects that are useful going forward. Let t be the total risk-tolerance of investors who participate in the stock-market (indexers and learners). Let i be the informativeness of the price implied by aggregating the precision choices of learning investors.

$$t = \int_{W_{0j}^{Particip}}^{W_{0j}^{max}} \frac{1}{\rho(W_{0j})} dj \tag{11}$$

$$t_d = \int_{W_{0j}^{Search}}^{W_{0j}^{max}} \frac{1}{\rho(W_{0j})} dj \tag{12}$$

$$s = \int_{W_{0j}^{Learn}}^{W_{0j}^{max}} \frac{1}{\rho(W_{0j})\sigma_{sji}^2} dj \tag{13}$$

$$n = s^{-1} \tag{14}$$

Proposition 2. *The price of the risky asset is given by $rp = a + bz - cx$, where:*

Proof. Market clearing implies that:

$$\underbrace{\int_{W_{0j}^{Particip}}^{W_{0j}^{Search}} q_j^{directly} dj}_{\text{Directly}} + \underbrace{\int_{W_{0j}^{Search}}^{W_{0j}^{max}} q_j^{delegate} dj}_{\text{Search and delegate}} = \underbrace{x}_{\text{Supply}} \tag{15}$$

$$t\left(\frac{\mu_z}{\sigma_z^2} + \frac{b}{c}\frac{\mu_x}{\sigma_x^2} + (z - \frac{cx}{b})\frac{b^2}{c^2}\sigma_x^{-2}\right) + sz - rp\left(n\left[\sigma_z^{-2} + \frac{b^2}{c^2}\sigma_x^{-2}\right] + s\right) = x$$

$$\left(\frac{\mu_z}{\sigma_z^2} + \frac{b}{c}\frac{\mu_x}{\sigma_x^2}\right) + z\left(\frac{b^2}{c^2}\sigma_x^{-2} + \frac{s}{t}\right) - x\left(\frac{b}{c}\sigma_x^{-2} - \frac{1}{t}\right) = rp\left(\sigma_z^{-2} + \frac{b^2}{c^2}\sigma_x^{-2} + \frac{s}{t}\right) \tag{16}$$

Plugging things in and given that investors who learn private information are correct on average, I can solve for rp in terms of z and x and then match the coefficients given that $a + bz - cx = rp$. This gives the price coefficients as:

$$a = \left[\frac{s}{t} + \sigma_z^{-2} + s^2\sigma_x^{-2}\right]^{-1}\left(\frac{\mu_z}{\sigma_z^2} + s\frac{\mu_x}{\sigma_x^2}\right) \tag{17}$$

$$b = \left[\frac{s}{t} + \sigma_z^{-2} + s^2\sigma_x^{-2}\right]^{-1}\left(s^2\sigma_x^{-2} + \frac{s}{t}\right) \tag{18}$$

$$c = \left[\frac{s}{t} + \sigma_z^{-2} + s^2\sigma_x^{-2}\right]^{-1}\left(s\sigma_x^{-2} + \frac{1}{t}\right) \tag{19}$$

Thus the price of the asset is:

$$rp = \left[\frac{s}{t} + \sigma_z^{-2} + s^2\sigma_x^{-2}\right]^{-1}\left[\left(\frac{\mu_z}{\sigma_z^2} + s\frac{\mu_x}{\sigma_x^2}\right) + \left(s^2\sigma_x^{-2} + \frac{s}{t}\right)z - \left(s\sigma_x^{-2} + \frac{1}{t}\right)x\right] \tag{20}$$

$$= h^{-1}\left[\left(\frac{\mu_z}{\sigma_z^2} + s\frac{\mu_x}{\sigma_x^2}\right) + \left(s^2\sigma_x^{-2} + \frac{s}{t}\right)z - \left(s\sigma_x^{-2} + \frac{1}{t}\right)x\right]$$

$$\text{where} \quad h_0 = \left[\sigma_z^{-2} + s^2\sigma_x^{-2}\right] \tag{21}$$

$$h(s, \sigma_{sj}^{-2}) = \sigma_{sj}^{-2} + h_0 = \left[\sigma_{sj}^{-2} + \sigma_z^{-2} + s^2\sigma_x^{-2}\right] \tag{22}$$

$$\bar{h} = h(\frac{s}{t}) = \left[\frac{s}{t} + \sigma_z^{-2} + s^2\sigma_x^{-2}\right] \tag{23}$$

■

Step 3. Find the indirect utility.

Plug the optimal portfolio into terminal wealth and taking its time-2 expectation and variance

$$W_{2j} = rW_{0j} - F - \omega - f_j + \left(\frac{\hat{\mu}_{zj} - rp}{\rho(W_{0j})\hat{\sigma}^2_{zj}}\right)[z - rp] \tag{24}$$

$$\text{then } E_2(W_{2j}) = rW_{0j} - F - \omega - f_j + \frac{1}{\rho(W_{0j})}\frac{(\hat{\mu}_{zj} - rp)^2}{\hat{\sigma}^2_{zj}} \tag{25}$$

$$var_2(W_{2j}) = var\left(\frac{\hat{\mu}_{zj} - rp}{\rho(W_{0j})\hat{\sigma}^2_{zj}} \times [z - rp]\right) = \frac{1}{\rho^2(W_{0j})}\frac{(\hat{\mu}_{zj} - rp)^2}{\hat{\sigma}^2_{zj}} \tag{26}$$

Plugging into the indirect utility (ex-ante utility) gives:

$$\begin{aligned}
U_{1j} &= E_1\left[E_2(W_{2j}|I_j) - \frac{\rho(W_{0j})}{2}var_2(W_{2j}|I_j)\right] \\
&= E_1\left[rW_{0j} - F - \omega - f_j + \frac{1}{\rho(W_{0j})}\frac{(\hat{\mu}_{zj} - rp)^2}{\hat{\sigma}^2_{zj}} - \frac{1}{2\rho(W_{0j})}\frac{(\hat{\mu}_{zj} - rp)^2}{\hat{\sigma}^2_{zj}}\right] \\
&= E_1\left[rW_{0j} - F - \omega - f_j + \frac{1}{2\rho(W_{0j})}\frac{(\hat{\mu}_{zj} - rp)^2}{\hat{\sigma}^2_{zj}}\right] \\
&= rW_{0j} - F - \omega - f_j + \frac{1}{2\rho(W_{0j})}E_1\left[\eta_j^2\right]
\end{aligned} \tag{27}$$

where $\eta_j = \frac{\hat{\mu}_{zj} - rp}{\sqrt{\hat{\sigma}^2_{zj}}}$.

So we want to compute $E_1\left[\eta_j^2\right] = E_1\left[\frac{(\hat{\mu}_{zj} - rp)^2}{\hat{\sigma}^2_{zj}}\right]$. This is perhaps the hardest step in this entire exercise.

$$\begin{aligned}
E_1[\eta_j^2] &= \left(\frac{\left[\sigma_{sj}^{-2} + \sigma_z^{-2} + s^2\sigma_x^{-2}\right]}{t^2\left[\frac{s}{t} + \sigma_z^{-2} + s^2\sigma_x^{-2}\right]^2}\right)\left[E(x^2) + t^2\left[\sigma_z^{-2} + s^2\sigma_x^{-2}\right] + 2st\right] - 1 = \\
&= \left[\sigma_{sj}^{-2} + \sigma_z^{-2} + s^2\sigma_x^{-2}\right]\underbrace{\left(\frac{1}{t^2\left[\frac{s}{t} + \sigma_z^{-2} + s^2\sigma_x^{-2}\right]^2}\right)\left[E(x^2) + t^2\left[\sigma_z^{-2} + s^2\sigma_x^{-2}\right] + 2st\right]}_{D} - 1 \\
&= \left[\sigma_{sj}^{-2} + \sigma_z^{-2} + s^2\sigma_x^{-2}\right]D - 1
\end{aligned} \tag{28}$$

To finish this section off, I obtained that the ex-ante time-1 utility is:

$$
\begin{aligned}
U_{1j} &= \max_{\sigma_{sj}^{-2}} rW_{0j} - F - \omega - f_j + \frac{1}{2}\frac{E_1\left[\eta_j^2\right]}{\rho(W_{0j})} = \\
&= \max_{\sigma_{sj}^{-2}} rW_{0j} - F - \omega - f_j + \frac{1}{2}\frac{\left(\sigma_{sj}^{-2} + \sigma_z^{-2} + s^2\sigma_x^{-2}\right)D - 1}{\rho(W_{0j})} && (29)\\
&\text{where} \quad D = \left(\frac{1}{t^2\left[\frac{s}{t} + \sigma_z^{-2} + s^2\sigma_x^{-2}\right]^2}\right)\left[E(x^2) + t^2\left(\sigma_z^{-2} + s^2\sigma_x^{-2}\right) + 2st\right] && (30)\\
&\text{simplifying gives:} \quad D = \left(\frac{1}{t^2\bar{h}^2}\right)\left[E(x^2) + t^2h_0 + 2st\right] && (31)
\end{aligned}
$$

Notice that the objective function in the ex-ante utility captures the information choice trade-off. Higher precision σ_{sj}^{-2} leads to higher information acquisition costs $\kappa(\sigma_{sji}^{-2})$ which translate into higher fees, $f_j(\sigma_{s,j}^{-2})$, thereby reducing ex-ante utility. On the other hand, higher precision σ_{sj}^{-2} increases the posterior precision $\hat{\sigma}_{zj}^{-2}$, the time-1 expected squared Sharpe ratio $E_1\left[\eta_j^2\right]$, and thus ex-ante utility.

How does D, the marginal benefit of learning private information change with s and t? Differentiating D, and remembering that $\bar{h} = \left[\frac{s}{t} + \sigma_z^{-2} + s^2\sigma_x^{-2}\right]$ gives $\frac{\partial D}{\partial t} < 0$ and $\frac{\partial D}{\partial s} < 0$, and $\frac{\partial D}{\partial n} > 0$.

Proposition 3. *The benefit of learning decreases as prices become more informative (ie. as s increases), and decreases as the total risk-tolerance of investors who participare in the stock-market increases (ie. as t increases). It increases with the amount of noise in the economy (ie. as n increases).*

Proof.

$$
\begin{aligned}
\frac{\partial D}{\partial t} &= \frac{\partial\left(\frac{E(x^2)+t^2\left[\sigma_z^{-2}+s^2\sigma_x^{-2}\right]+2st}{t^2\left[\frac{s}{t}+\sigma_z^{-2}+s^2\sigma_x^{-2}\right]^2}\right)}{\partial t} = \frac{\partial\left(\frac{t^{-2}E(x^2)+\left[\sigma_z^{-2}+s^2\sigma_x^{-2}\right]+2st^{-1}}{\left[st^{-1}+\sigma_z^{-2}+s^2\sigma_x^{-2}\right]^2}\right)}{\partial t} = \\
&= \frac{[-2t^{-3}E(x^2) - 2st^{-2}]\bar{h}^2 - [t^{-2}E(x^2) + \left(\sigma_z^{-2} + s^2\sigma_x^{-2}\right) + 2st^{-1}]2\bar{h}(-2st^{-2})}{\bar{h}^4} = \\
&= \frac{-2}{t^2\bar{h}^3} \times \left[(n^{-1}E(x^2) + s)(\frac{s}{t} + \left(\sigma_z^{-2} + s^2\sigma_x^{-2}\right)) - (t^{-2}E(x^2) + \left(\sigma_z^{-2} + s^2\sigma_x^{-2}\right) + 2st^{-1})i\right] \\
&= \frac{-2}{t^3\bar{h}^3} \times \left[E(x^2)\left(\sigma_z^{-2} + s^2\sigma_x^{-2}\right) - s^2\right] = \frac{-2}{t^3\bar{h}^3} \times \left[E(x^2)\sigma_z^{-2} + s^2(\frac{E(x^2)}{\sigma_x^2} - 1)\right] = \\
&= \frac{-2}{t^3\bar{h}^3} \times \left[E(x^2)\sigma_z^{-2} + s^2(\frac{\sigma_x^2 + \mu_x^2}{\sigma_x^2} - 1)\right] = \frac{-2}{t^3\bar{h}^3} \times \left[E(x^2)\sigma_z^{-2} + s^2\frac{\mu_x^2}{\sigma_x^2}\right] < 0 && (32)
\end{aligned}
$$

$$
\text{and } \frac{\partial D}{\partial s} = \frac{\partial\left(\frac{E(x^2)+t^2\left[\sigma_z^{-2}+s^2\sigma_x^{-2}\right]+2st}{t^2\left[st^{-1}+\sigma_z^{-2}+s^2\sigma_x^{-2}\right]^2}\right)}{\partial i} = \frac{\partial\left(\frac{t^{-2}E(x^2)+\left[\sigma_z^{-2}+s^2\sigma_x^{-2}\right]+2st^{-1}}{\left[st^{-1}+\sigma_z^{-2}+s^2\sigma_x^{-2}\right]^2}\right)}{\partial s} =
$$

$$= \frac{(2s\sigma_x^{-2} + 2t^{-1})\bar{h}^2 - [t^{-2}E(x^2) + \sigma_z^{-2} + s^2\sigma_x^{-2} + 2st^{-1}]2\bar{h}(t^{-1} + 2i\sigma_x^{-2})}{\bar{h}^4} =$$
$$= \frac{2}{\bar{h}^3}\left[(i\sigma_x^{-2} + t^{-1})(h_0 + st^{-1}) - [t^{-2}E(x^2) + \sigma_z^{-2} + s^2\sigma_x^{-2} + 2st^{-1}](t^{-1} + 2i\sigma_x^{-2})\right] =$$
$$= \frac{-2}{\bar{h}^3}\left[t^{-3}E(x^2) + st^{-2} + 2st^{-2}E(x^2)\sigma_x^{-2} + s\sigma_x^{-2}\sigma_z^{-2} + s^3\sigma_x^{-4} + 3s^2t^{-1}\sigma_x^{-2}\right] < 0 \tag{33}$$

$$\text{and, given } n = s^{-1}\text{, implicitly gives: } \frac{\partial D}{\partial n} > 0 \tag{34}$$

■

I define the market inefficiency, θ, as

$$\theta = (U_{1j}^{delegate} - U_{1j}^{directly})\rho(W_{0j})$$

. Note that $U_{1j}^{delegate} - U_{1j}^{directly} = \frac{1}{2}\frac{\sigma_{s,j}^{-2}D}{\rho(W_{0j})}$, so the price inefficiency is given by:

$$\theta = \frac{\sigma_{s,j}^{-2}D}{2} = \frac{\sigma_{s,j}^{-2}}{2}\left(\frac{E(x^2) + t^2\left(\sigma_z^{-2} + s^2\sigma_x^{-2}\right) + 2st}{t^2\left[\frac{s}{t} + \sigma_z^{-2} + s^2\sigma_x^{-2}\right]^2}\right) \tag{35}$$

Step 4. Find the asset management fees

The asset management fee f_j is set through Nash bargaining between an investor and a manager, maximizng the product of the utility gains from agreement. If no agreement is reached, the investor's outside option is to invest uninformed on his own yielding a utility of

$$(rW_{0j} - F - \omega + U_{1j}^{directly})$$

. The utility of searching for another manager is

$$(rW_{0j} - F - \omega - f_j + U_{1j}^{delegate})$$

. For an asset manager, the gain from agreement is the fee f_j, as the cost of acquiring information $\kappa(.)$ is sunk, and there is no marginal cost of taking on the investor.

Proposition 4. *The asset management fee is given by f_j. It increases with the level of market inefficiency and with the investor's initial wealth.*

Proof.

$$\max_{f_j}\ (U_{1j}^{delegate} - U_{1j}^{directly} - f_j)f_j \tag{36}$$
$$[FOC:]\ (U_{1j}^{delegate} - U_{1j}^{directly}) = 2f_j$$
$$f_j = \frac{U_{1j}^{delegate} - U_{1j}^{directly}}{2} = \frac{\theta}{2\rho(W_{0,j})} = \frac{\theta W_{0,j}}{2\rho} \tag{37}$$

Note that

$$\frac{\partial f_j}{\partial \theta} = \frac{1}{2\rho(W_{0j})} > 0 \text{ and } \frac{\partial f_j}{\partial W_{0j}} = \frac{\theta}{2\rho} > 0 \tag{38}$$

■

The fee would naturally be zero if asset markets were perfectly efficient, so that investors had no benefit from searching for an informed manager. In this setting, active asset managemenet fees can be construed as evidence that retail investors believe that security markets are not fully efficient.

Step 5. Decision to delegate

An investor optimally decides to look for an informed asset manager, as long as the utility difference from doing so is at least as large as the cost of searching and paying the asset management fee:

$$U_{1j}^{delegate} - U_{1j}^{directly} \geq \omega + f_j \tag{39}$$

$$\frac{\theta}{\rho(W_{0j})} \geq \omega + f_j \tag{40}$$

$$\omega = \frac{\theta}{2\rho(W_{0j})} \tag{41}$$

Step 6. Find the optimal precision.

Proposition 5. *The managers' optimal precision choice is given by* $\sigma_{s,m}^{-2} = \frac{sD-4c_1}{4c_0}$.

Proof. Each manager has the option to choose how much information to learn. Let's assume a concrete form for the cost of acquiring information about the stochastic asset: $\kappa(\hat{\sigma}_{z,m}^{-2}) = \frac{1}{2}c_1(\hat{\sigma}_{z,m}^{-2})^2 + c_0\hat{\sigma}_{z,}^{-2}$. As mentioned before, the cost is increasing and convex in the precision of information learned. This means that more precise information is more costly to acquire. In addition, no manager can acquire perfect information because that would be too costly. The managers' problem is thus to choose the posterior precision $\hat{\sigma}_{z,m}^{-2}$.

For a manager, the benefit of learning is the fee obtained from all the investors delegating to that manager. There is a total mass one of managers, and the cost of learning is $\kappa(\sigma_{z,m}^{-2})$. Thus, in an interior equilibrium, the manager's marginal benefit of learning has to equal his marginal cost of learning.

$$\int_{W_{0j}^{Search}}^{W_{0j}^{max}} f_j dj = \kappa'(\sigma_{s,m}^{-2}) \implies \frac{sD}{4} = \kappa'(\sigma_{s,m}^{-2}) \implies \tag{42}$$

$$\implies \frac{sD}{4} = c_1\sigma_{s,m}^{-2} + c_0 \implies \sigma_{s,m}^{-2} = \frac{sD-4c_1}{4c_0} \tag{43}$$

■

How does precision depend on aggregate risk-tolerance, informativeness and noise?

$$\frac{\partial \hat{\sigma}_{s,m}^{-2}}{\partial t} < 0 \tag{44}$$

$$\text{and} \quad \frac{\partial \hat{\sigma}_{s,m}^{-2}}{\partial s} < 0 \text{ in the limit} \tag{45}$$

$$\frac{\partial \hat{\sigma}_{s,m}^{-2}}{\partial \kappa} < 0 \tag{46}$$

$$\text{and} \quad \frac{\partial \hat{\sigma}_{s,m}^{-2}}{\partial n} > 0 \tag{47}$$

Step 7. Derive the wealth thresholds.

I will now first derive the level of initial wealth at which agents enter stock-markets. The level of wealth that makes an agent indifferent betweeen being a non-stockholder and a stock-holder of any risky asset is given by:

$$\underbrace{V^{Particip}}_{W_{2j}|(\sigma_{sji}^{-2}=0)} = \underbrace{V^{NotParticip}}_{rW_{0j}^{Particip}} \tag{48}$$

The value of not participating is given by $W_{0j}^{Particip}$, while the value of participating can be solved explicitly from the budget constraint in **??** plugging in $\sigma_{sji}^{-2} = 0$:

$$\begin{aligned}
& rW_{0j}^{Particip} - F + \frac{1}{2}\frac{\left(0 + \sigma_z^{-2} + s^2\sigma_x^{-2}\right)D - 1}{\rho(W_{0j}^{Particip})} = rW_{0j}^{Particip} \\
& \frac{\left[\left(\sigma_z^{-2} + s^2\sigma_x^{-2}\right)D - 1\right]}{2\rho(W_{0j}^{Particip})} = F \\
& W_{0j}^{Particip} = \rho^{inv}\left(\frac{\left[\left(\sigma_z^{-2} + s^2\sigma_x^{-2}\right)D\right] - 1}{2F}\right) \\
& W_{0j}^{Particip} = \frac{2\rho F}{\left[\left(\sigma_z^{-2} + s^2\sigma_x^{-2}\right)D\right] - 1}
\end{aligned} \tag{49}$$

where I plugged in $\rho(W_{0j}) = \frac{\rho}{W_{0j}}$ and $W_{0j} = \rho^{inv}(\frac{\rho}{W_{0j}})$ and where D is defined above.

For the marginal delegating investor, the following holds with equality

$$U_j^{delegate} - \omega - f_j > U_j^{directly}$$

This implies:

$$\frac{\theta}{\rho(W_{0,j})} = \omega + f_j \implies \frac{\theta}{\rho(W_{0,j})} = \omega + \frac{\theta}{2\rho(W_{0,j})} \tag{50}$$

$$\implies \frac{\theta}{2\rho(W_{0,j})} = \omega \implies \frac{\rho\omega}{W_{0,j}} = \frac{\theta}{2} \implies W_{0,j}^{search} = \frac{2\rho\omega}{\theta} \tag{51}$$

This means that an investor j should delegate to an active manager if she has large wealth $W_{0,j}$, low relative risk-aversion ρ, low absolute risk-aversion $\rho(W_{0,j})$, or low search cost ω, all relative to the asset market inefficiency θ. That is if

$$\frac{\rho\omega}{W_{0,j}} \leq \frac{\theta}{2} \tag{52}$$

Step 8. Extension: Managers Free-Entry

Let M be the number of active managers.

Proposition 6. *The number of managers is given by*

$$M = \frac{sD}{4\kappa'(\sigma_{s,m}^{-2})}$$

Proof. For an uninformed manager to enter, the expected extra fee revenue has to cover the cost of information,

$$\frac{sD}{4M} \geq \kappa'(\sigma_{s,m}^{-2})$$

. This condition has to hold with equality for an interior equilibrium. To simplify the algebra, assume the cost of acquiring information is linear $\kappa = c_1\sigma_{s,m}^{-2}$. Then,

$$\frac{sD}{4M} = \kappa'(\sigma_{s,m}^{-2} \tag{53}$$

$$\frac{sD}{4M} = c_1\sigma_{s,m}^{-2} \tag{54}$$

$$M = \frac{sD}{4c_1\sigma_{s,m}^{-2}} \tag{55}$$

■

Proposition 7. *The managers' condition is hump-shaped because of crowding out of information.*

Proof. Notice that sD is a concave function in s. When the number of searching investors increases from zero, the number of informed managers also increases from zero, since managers are encouraged to earn the fees paid by searching investors. M depends on both s and $D(s)$, which is a decreasing function of s.

Initially, the increase in s dominates the decrease in $D(s)$. However, after a point, the decrease in $D(s)$ dominates the increase in s, hence the hump-shaped form of M.

After a certain threshold, the fees a manager gets decrease with the number of delegating investors. this is because active investment increases market efficiency, and reduces the value of asset management services. Hence, when so many invesots have searched and delegated their portfolios that the reduction in the benefit of acquiring information dominates (ie. the reduction in $D(s)$ dominates), additional search and delegation decreases the number of informed managers. ■

2 No investor acquires information independently

A plausible equilibrium in one in which investors do not learn private information on their own, but prefer to delegate their investment to an asset manager. This implies:

$$u_j^i - \kappa(\sigma_{s,j}^{-2}) \leq u_j^i - \omega - f_j \tag{56}$$

$$\kappa(\sigma_{s,j}^{-2}) \geq \omega + \frac{\theta}{2\rho(W_{0j})} \tag{57}$$

$$\omega = \kappa(\sigma_{s,j}^{-2}) - \frac{\theta}{2\rho(W_{0j})} = \kappa(\sigma_{s,j}^{-2}) - \frac{\sigma_{s,j}^{-2} D}{4\rho(W_{0j})} \tag{58}$$

So, provided that $\omega \geq \kappa(\sigma_{s,j}^{-2}) - \frac{\sigma_{s,j}^{-2} D}{4\rho(W_{0j})}$, an investor prefers using an asset manager to acquiring signals singlehandedly.

Proofs: Asset management

Theorem 1. *In a general equilibrium for assets and asset management:*

1. *Informed asset managers outperform uninformed investing (before and after fees).*

$$u_j^{delegate} - f_j \geq u_j^{directly}$$

2. *Holding fixed other characteristics, wealthier investors who delegate their portfolios (higher W_{0j}) earn higher expected returns (before and after fees) and pay lower percentage fees, on average.*

Proof. Part 1. follows from the fact that investors who match with informed managers choose to pay the fee and invest with the manager rather than invest directly as uninformed. We know that

$$\theta = (U_j^{delegate} - U_j^{directly})\rho(W_{0,j}), \text{ from definition of } \theta, \text{ and} \tag{59}$$

$$f_j = \frac{\theta}{2\rho(W_{0,j})}, \text{ from Nash bargaining} \tag{60}$$

Substituting into what we want to prove: $U_j^{delegate} - U_j^{directly} > f_j$ gives $\frac{\theta}{\rho(W_{0,j})} > \frac{\theta}{2\rho(W_{0,j})}$, which is obviously true.

Note that the indifference condition for the active delegating investor is $U_j^{delegate} - f_j - U_j^{directly} = \omega$. The outperformance is clearly larger if the equilibrium ω is larger.

■

Proof. Part 2. We want to compute the expected return on the wealth invested with an active manager, under the assumption that all managers get investors with wealth higher than $W_{0,j}^{search}$, and have absolute risk-aversion $\rho(W_{0,j})$ and relative risk-aversion ρ.

Given total wealth under management: $W^m = \int_{W_{0,j}^{search}}^{W_{0,j}^{max}} dj$, the manager invests as an agent with absolute risk-aversion $\rho^m = \frac{\rho}{W_m}$. It is clear that all investors with an informed managers achieve the same gross excess return. The expected gross return is computed as the total dollar profit per capital invested W^m using the fact that the aggregate position is: $q^{delegate} = \frac{E[z|s,p]-rp}{\rho^m var[z|s,p]} = \frac{\hat{\mu}_z^I - rp}{\rho^m \hat{\sigma}_z^{2I}}$. The expected gross return in then:

$$R^I = \frac{1}{2\rho^m} E\left[\left(\frac{\hat{\mu}_z^I - rp}{\rho^m\sqrt{\hat{\sigma}_z^{2I}}}\right)^2\right] = \frac{1}{2\rho^m} E\left[\eta^{2I}\right] \tag{61}$$

$$R^U = \frac{1}{2\rho(W_{0,j})} E\left[\left(\frac{\hat{\mu}_z^U - rp}{\rho(W_{0,j})\sqrt{\hat{\sigma}_z^{2U}}}\right)^2\right] = \frac{1}{2\rho(W_{0,j})} E\left[\eta^{2U}\right] \tag{62}$$

The goal is to show that $R^I > R^U$. Note that the average risk-tolerance of investors delegating with an active manager is also larger than the tolerance of an uninformed investor, $1/\rho^m > 1/\rho(W_{0,j})$. There are two reasons why it holds. The first is better information, the second is lower risk. Better information is because

$$E\left[(\hat{\mu}_z^I - rp)^2\right] > E\left[(\hat{\mu}_z^I - rp)^2\right]$$

and lower risk

$$E\left[\left(\frac{1}{\sqrt{\hat{\sigma}_z^{2I}}}\right)^2\right] > E\left[\left(\frac{1}{\sqrt{\hat{\sigma}_z^{2U}}}\right)^2\right]$$

The second effect is not necessary for the result. As for the first effect, it follows immediately from Jensen's inequality, conditional on p.

It can also be easily seen given:

$$E\left[\eta^{2I}\right] = \left(\sigma_{s,m}^{-2} + \sigma_z^{-2} + s^2\sigma_x^{-2}\right) D - 1 \tag{63}$$

$$E\left[\eta^{2U}\right] = \left(\sigma_z^{-2} + s^2\sigma_x^{-2}\right) D - 1 \tag{64}$$

It is clear $E\left[\eta^{2I}\right] > E\left[\eta^{2U}\right]$ because $\sigma_{s,m}^{-2} D > 0$, as $\sigma_{s,m}^{-2} > 0$, and $D > 0$.

■

Proposition 8. *Consider now the expected return of an investor with a manager, conditional on investors' characteristics. This is increasing in initial wealth.*

Proof.

$$E[R^I|W_{0,j}, \rho(W_{0,j}), \omega] = pr\left(\rho\omega \leq \frac{W_{0,j}\theta}{2}\right) \frac{\left(\sigma_{s,m}^{-2} + \sigma_z^{-2} + s^2\sigma_x^{-2}\right) D - 1}{2\rho^m} \tag{65}$$

where $pr\left(\rho\omega \leq \frac{W_{0,j}\theta}{2}\right)$ increases with $W_{0,j}$.

Percentage fees for a given investors are decreasing in $W_{0,j}$ too, because they are a fixed multiple of $\frac{\rho\omega}{W_{0,j}}$ which is decreasing in $W_{0,j}$. ■

Proposition 9. *In a general eequilibrium for asset managers:*

1. *Managers' returns, before and after fees, and their average investor size covary positively.*
2. *Manager size and expected returns, before and after fees, covary positively. Similarly, managers with a comparative advantage in collecting information, $\kappa_m \leq \kappa_{m'}$ earn higher expected returns before and after fees.*

Proof. Part 1. Asset managers are identical in this framework. We want to show that $cov\left(R^m, W^m\right) > 0$. Rewriting,

$$cov\left(R^m, W^m\right) = cov\left(R^I, W^m\right) = cov\left(\frac{1}{2\rho^m}E\left[\eta^{2I}\right], W^m\right) = \tag{66}$$

$$= cov\left(\frac{W^m}{2\rho}E\left[\eta^{2I}\right], W^m\right) = \frac{E\left[\eta^2\right]}{2\rho} > 0 \tag{67}$$

■

Proof. finish part 2. ■

When participation costs fall

How do the wealth thresholds change with F?

$$\frac{\partial W_{0j}^{Particip}}{\partial F} = \frac{2\rho}{\left[\left(\sigma_z^{-2} + s^2\sigma_x^{-2}\right)D\right] - 1} > 0 \tag{68}$$

$$\text{while } \frac{\partial W_{0j}^{Search}}{\partial F} = \frac{-2\rho F}{1} < 0 \tag{69}$$

How does the equity premium and the variance of returns change with F?

The equity premium is given by:

$$EqPr = \frac{\mu_x}{\bar{h}t} = \frac{\mu_x}{\left[s + t\sigma_z^{-2} + s^2 t\sigma_x^{-2}\right]}$$

Proof. While F does not enter directly in the formula for the equity premium, it indirectly affects it by its effect on aggregate risk tolerance. A lower entry cost F implies a higher aggregate risk tolerance t, which translates into a lower equity premium as

$$\frac{\partial EqPr}{\partial t} = \frac{\partial \frac{\mu_x}{\bar{h}t}}{\partial t} = -\frac{\mu_x(\sigma_z^{-2} + s^2\sigma_x^{-2})}{\underbrace{\left[s + t\sigma_z^{-2} + s^2 t\sigma_x^{-2}\right]^2}_{+}} < 0 \tag{70}$$

■

As for the variance of returns, plugging in the coefficients:

$$\begin{aligned} var(z-rp) &= (1-b)^2\sigma_z^2 + c^2\sigma_x^2 = \\ &= \left(1 - \frac{\left(s^2\sigma_x^{-2} + \frac{s}{t}\right)}{\left[\frac{s}{t} + \sigma_z^{-2} + s^2\sigma_x^{-2}\right]}\right)^2 \sigma_z^2 + \frac{\left(s\sigma_x^{-2} + \frac{1}{t}\right)^2}{\left[\frac{s}{t} + \sigma_z^{-2} + s^2\sigma_x^{-2}\right]}\sigma_x^2 = \\ &= \frac{\sigma_z^{-2}}{\left[\frac{s}{t} + \sigma_z^{-2} + s^2\sigma_x^{-2}\right]^2} + \frac{\left(s\sigma_x^{-2} + \frac{1}{t}\right)^2\sigma_x^2}{\left[\frac{s}{t} + \sigma_z^{-2} + s^2\sigma_x^{-2}\right]} \end{aligned} \tag{71}$$

Proof. The derivative of the variance of returns is more complex:

$$\begin{aligned} \frac{\partial var(z-rp)}{\partial t} &= \frac{2s\sigma_z^{-2}}{\left(\frac{s}{t} + \frac{1}{\sigma_z^2} - \frac{1}{\sigma_x^2}\right)^3 t^2} + \frac{\sigma_x^2\sigma_z^2\left(\mathrm{s}t + \sigma_x^2\right)\left[\left(\sigma_z^2 - 2\sigma_x^2\right)t - \mathrm{s}\sigma_x^2\sigma_z^2\right]}{t^2\left[\left(\sigma_z^2 - \sigma_x^2\right)t - \mathrm{s}\sigma_x^2\sigma_z^2\right]^2} = \\ &= -\frac{2\sigma_x^2\left(\frac{1}{t} + \frac{\mathrm{s}}{\sigma_x^2}\right)}{\left(\frac{\mathrm{s}}{t} + \frac{1}{\sigma_z^2} - \frac{1}{\sigma_x^2}\right)t^2} + \frac{\mathrm{s}\sigma_x^2\left(\frac{1}{t} + \frac{\mathrm{s}}{\sigma_x^2}\right)^2}{\left(\frac{\mathrm{s}}{t} + \frac{1}{\sigma_z^2} - \frac{1}{\sigma_x^2}\right)^2 t^2} + \frac{2\mathrm{s}}{\sigma_z^2\left(\frac{\mathrm{s}}{t} + \frac{1}{\sigma_z^2} - \frac{1}{\sigma_x^2}\right)^3 t^2} \\ &< 0, \text{ verified numerically} \end{aligned} \tag{72}$$

This expression's sign is ambiguous to solve pen and paper and depends on the magnitude of the parameters. In a simulation where all variances are equal to 1, and I assume that $s = 0.5$, then as t increases (while $t > 0$), the variance of returns decreases. This holds numerically for different values of s. ■

When research costs fall

How do the wealth thresholds change with information costs $\sum_{i=1}^{N}\kappa(\sigma_{sji}^{-2})$? This is harder to calculate, but broadly, it is equivalent to calculating the change with respect to i, bearing in mind that a larger cost κ implies a lower i.

$$\frac{\partial W_{0j}^{Particip}}{\partial i} = \frac{\partial \frac{2\rho F}{\sum_{i=1}^{N}[\left(\sigma_z^{-2} + i^2\sigma_x^{-2}\right)D_i] - N}}{\partial i} = \frac{\partial 2\rho F[\sum_{i=1}^{N}[\left(\sigma_z^{-2} + i^2\sigma_x^{-2}\right)D_i] - N]^{-1}}{\partial i} \tag{73}$$

$$= -2\rho F[\sum_{i=1}^{N}[\left(\sigma_z^{-2} + i^2\sigma_x^{-2}\right)D_i] - N]\frac{\partial i^2\sigma_x^{-2}D_i}{\partial i} \tag{74}$$

$$= - \underbrace{2\rho F[\sum_{i=1}^{N}[\left(\sigma_z^{-2} + i^2\sigma_x^{-2}\right)D_i] - N]i\sigma_x^{-2}}_{positive}\underbrace{(2D_i + i\partial D_i/\partial i)}_{likelypositive}$$

$$< 0 \tag{75}$$

Remember that $\partial D/\partial s < 0$. Signing $2D_i + i\partial D_i/\partial i$ and plugging in $\bar{h} = \left[\frac{i}{t} + \sigma_z^{-2} + i^2\sigma_x^{-2}\right]$ and $h_0 = \left[\sigma_z^{-2} + i^2\sigma_x^{-2}\right]$ gives:

$$\text{sign}(2D_i + i\partial D_i/\partial i) = sign\{\left(\frac{2}{t^2\bar{h}^3}\right)[E(x_i^2)\bar{h} + t^2h_0\bar{h} + 2in\bar{h}] - \frac{2i}{t^2\bar{h}^3}[n^{-1}E(x_i^2) +$$

$$+ i + 2iE(x_i^2)\sigma_x^{-2} + it^2\sigma_x^{-2}\sigma_z^{-2} + i^3t^2\sigma_x^{-4} + 3i^2n\sigma_x^{-2}]\} =$$
$$= sign\{E(x_i^2)(\sigma_z^{-2} - i^2\sigma_x^{-2}) + 3in\sigma_z^{-2} + t^2\sigma_z^{-4} + i^2t^2\sigma_z^{-2}\sigma_x^{-2} + i^2\} = \text{likely positive}$$

This means that the higher the s (the lower the cost of info acquisition), the higher the wealth threshold for participation.

Changes in aggregate risk tolerance t and information s:

This section goes in the Appendix. In the first equilibrium category, $W_0^{Search} > W_0^{Particip}$. Agents with wealth between $W_0^{Particip}$ and W_0^{Search} participate, but do not acquire information. Hence, the total risk-tolerance in the economy is $t = \int_{W_0^{Particip}}^{W_0^{Max}} \frac{1}{\rho(W_{0j})} dB(W_{0j})$ and the total information in the economy is $s = \int_{W_0^{Search}}^{W_0^{Max}} \frac{\sigma_{s,m}^{-2}}{\rho(W_{0j})} dB(W_{0j})$.

Define $n = s^{-1}$ to be the total noise in this economy.

Differentiating the equation that defines the aggregate amount of information yields:

$$ds = \underbrace{-\frac{1}{\rho(W_{0j}^{Search})}\sigma_{s,m}^{-2}(W_{0j}^{Search})b(W_{0j}^{Search})dW_{0j}^{Search}}_{\text{extensive margin}} + \underbrace{\int_{W_0^{Search}}^{W_0^{Max}} d\sigma_{s,m}^{-2}(W_j)\frac{1}{\rho(W_j)}dB(W_j)}_{\text{intensive margin}} \tag{76}$$

where the first term is differentiating the upper bound in the integral, and the second term is differentiating the integrand.

Differentiating the expression for W_{0j}^{Search} yields:

$$dW_{0j}^{Search} = \frac{\left(\rho^{-1}(W_{0j}^{Search})\right)}{\left(\rho^{-1}(W_{0j}^{Search})\right)'}\left[-\frac{\partial D}{D} + \frac{1}{\kappa'(0)}\frac{\partial \kappa'(0)}{\partial k}dk\right] \tag{77}$$

Given that $(\partial D)/(\partial n) > 0$ while $(\partial D)/(\partial t) < 0$, it has to be the case that W_{0j}^{Search} is decreasing in n and increasing in t, holding k constant. Differentiating the information choice **??** yields:

$$d\sigma_{s,m}^{-2} = \frac{1}{\kappa''(\sigma_{s,m}^{-2})}\left[\frac{1}{2r\rho(W_j)}\left(\frac{\partial D}{\partial n}dn + \frac{\partial D}{\partial s}ds\right) - \frac{\partial \kappa'(\sigma_{s,m}^{-2})}{\partial k}dk\right] \tag{78}$$

where $\sigma_{s,m}^{-2}$ is increasing in n and decreasing in t holding k constant. Finally, notice that $dn = -n^2 ds$. Putting these elements together,

$$A_t dt + A_n dn = A_k dk \tag{79}$$

$$\text{where } \mathcal{I} \equiv \int_{W_0^{Search}}^{W_0^{max}} \frac{1}{2r\rho^2(W_j)\kappa''(\sigma_{s,m}^{-2})}dB(W_j) + \frac{\sigma_{s,m}^{-2}b(W^{Search})}{\rho^2(W_j)D\left(\rho^{-1}(W_{0j}^{Search})\right)'} > 0 \tag{80}$$

$$A_t \equiv \frac{\partial D}{\partial t}s^{-2}\mathcal{I} < 0 \tag{81}$$

$$A_n \equiv 1 + \frac{\partial D}{\partial n} n^2 \mathcal{I} > 0 \tag{82}$$

$$\text{and } A_k \equiv n^2 \int_{W_0^{Search}}^{W^{max}} \frac{\partial \kappa'(\sigma_{s,m}^{-2})}{\rho(W_j)\kappa''(\sigma_{s,m}^{-2})\partial k} dB(W_j) + \frac{2rn^2 \partial \kappa'(0)}{D\left(\rho^{-1}(W_{0j}^{Search})\right)' \partial k} > 0 \tag{83}$$

Differentiating the equation that defines the aggregate tolerance in the economy yields:

$$dt = -\frac{1}{\rho(W_{0j}^{Particip})} b(W_{0j}^{Particip}) dW_{0j}^{Particip} \tag{84}$$

Plugging in the threshold for participation **??** gives:

$$\begin{aligned} dW_{0j}^{Particip} &= -\frac{2rF}{[\left(\sigma_z^{-2} + s^2\sigma_x^{-2}\right)D - 1]^2 (\rho^{-1}(W_{0j}^{Particip}))'} \Big[\left((\sigma_z^{-2} + s^2\sigma_x^{-2})\frac{\partial D}{\partial n} - \frac{2D}{n^3\sigma_x^2}\right) dn + \\ &+ (\sigma_z^{-2} + s^2\sigma_x^{-2})\frac{\partial D}{\partial t} dt\Big] + \frac{2r}{[\left(\sigma_z^{-2} + s^2\sigma_x^{-2}\right)D - 1](\rho^{-1}(W_{0j}^{Particip}))'} dF \end{aligned} \tag{85}$$

Plugging back leads to

$$G_t dt + G_n dn = G_F dF \tag{86}$$

$$\text{where } G_t \equiv -\frac{(\rho^{-1}(W_{0j}^{Particip}))'}{\rho^{-1}(W_{0j}^{Particip}) b(W^{Particip})} \frac{((\sigma_z^{-2} + s^2\sigma_x^{-2})D - 1)2}{2rF} + (\sigma_z^{-2} + s^2\sigma_x^{-2})\frac{\partial D}{\partial t} < 0 \tag{87}$$

$$G_n \equiv (\sigma_z^{-2} + s^2\sigma_x^{-2})\frac{\partial D}{\partial n} - \frac{2D}{n^3\sigma_x^{-2}} > 0 \tag{88}$$

$$G_F \equiv \frac{2r}{(\sigma_z^{-2} + s^2\sigma_x^{-2})D - 1} > 0 \tag{89}$$

This is a system of two linear equations in two unknowns dt and dn. The solution is:

$$dt = \frac{A_n G_F}{\Delta} dF - \frac{G_n A_k}{\Delta} dk \tag{90}$$

$$dn = -\frac{A_t G_F}{\Delta} dF + \frac{G_t A_k}{\Delta} dk \tag{91}$$

where $\Delta \equiv A_n G_t - G_n A_t < 0$.

It remains to be shown that $\Delta < 0$. For this, note that by replacing the coefficients with their expressions, and dropping the term that appears in every relation $\frac{(\rho^{-1}(W_0^P articip))'}{\rho^{-1}(W_0^P articip) b(W_0^P articip)} > 0$

$$-\frac{G_t}{G_n} > -\frac{\partial D/\partial t}{\partial D/\partial n} > -\frac{A_t}{A_n} \tag{92}$$

It sufficies to show that

$$-\frac{(\sigma_z^{-2}+s^2\sigma_x^{-2})\frac{\partial D}{\partial t}}{\left[(\sigma_z^{-2}+s^2\sigma_x^{-2})\frac{\partial D}{\partial n}-\frac{2D\sigma_x^{-2}}{n^3}\right]} > -\frac{\frac{\partial D}{\partial t}}{\frac{\partial D}{\partial n}} > -\frac{\frac{\partial D}{\partial t}n^2\mathcal{I}}{\left[1+\frac{\partial D}{\partial n}n^2\mathcal{I}\right]} \tag{93}$$

This inequality (93) is trivially satisfied since all these terms are positive: $\frac{\partial D}{\partial n} > 0$, and $\mathcal{I} > 0$, and $G_n \equiv \left[(\sigma_z^{-2}+s^2\sigma_x^{-2})\frac{\partial D}{\partial n}-\frac{2D\sigma_x^{-2}}{n^3}\right] > 0$.

From the signs of the different coefficients it follows that:

$$\frac{dt}{dk} > 0 \tag{94}$$

$$\frac{dn}{dk} > 0 \implies \frac{ds}{dk} < 0 \tag{95}$$

$$\frac{dt}{dF} < 0 \tag{96}$$

$$\frac{dn}{dF} < 0 \implies \frac{ds}{dF} > 0 \tag{97}$$

Thus, informativeness increases if the search and information cost fall, and decreases if the entry cost falls. Aggregate participation levels decrease if the search or information costs fall, and rise if the entry cost falls.

3 Links between ICT and poverty and inequality

Main topic	Question	Result	Authors
ICT, growth, poverty	What is the role of ICT for economic growth?	Investment in ICT promotes economic growth	Pohjola (2001), Colecchia & Schreyer (2002)
		ICT reduces production costs and increase output	Vu (2011, 2013)
		ICT increases employment opportunities and demand	Datta & Agarwal (2004)
	What is the role of ICT in poverty reduction?	ICT reduces poverty reduction and are powerful tool to access education, health and financial services	Kenny (2002), Cecchini & Scott (2003), Shamim (2007), Warren (2007), Bhavnani et al. (2008), Sassi & Goaied (2013), Pradhan et al. (2015)
ICT, financial inclusion	What is the role of ICT in promotion of financial inclusion?	They suggest favorable effects of ICT for economic growth through financial inclusion	Kpodar & Andrianaivo (2011)
	Does ICT/mobile banking affect the poor ?	ICT and mobile technology promote financial inclusion particularly in rural areas	Kendall et al. (2010), Sarma & Pais (2011), Mishra & Bisht (2013)
		Mobile banking improves the economic conditions of the poor	Mbiti & Weil (2011)
		Mobile money technology affects entrepreneurship and economic growth positively	Beck et al. (2015)
Access to finance and poverty	Does access to finance lower poverty and promote household welfare?	Rich and wealthy households are more likely to have a bank account in countries with higher foreign bank presence	Beck & Brown (2011)
		Access to finance has a potential to reduce poverty and increase employment in low income regions	Bruhn & Love (2014)
		Socio-economic conditions can be improved through advancing financial inclusion	Alter (2015)
	Financial Access and Inequality	Show a negative correlation between financial access (bank account) and inequality	Honohan (2008), Park & Mercado Jr (2015)
ICT and stock-market participation	What is the role of ICT for stock-market participation?	A positive impact of access to and use of Computer/Internet on stock market participation.	Bogan (2008), Servon & Kaestner (2008)

		Financial literacy is significantly related to financial markets participation; it also discourages informal borrowing.	Klapper et al. (2013)
		Financial literacy and schooling attainment have the positive effects on household wealth accumulation. It could have much larger benefits for individuals, firms, economy and government if they invest more in financial literacy.	Van Rooij et al. (2011), Behrman et al. (2010), Thomas & Spataro (2015)
	Impact of ICT on entrepreneurship	Online banking, behavior and banking relations help reduce perceived financial problems for the entrepreneurs; improves innovation and access to credit.	Han (2008), Ayyagari et al. (2011), Dalla Pellegrina et al. (2017)
	How does ICT impact risk and insurance?	Mobile money facilitates risk-spreading. The geographic reach of networks can enlarge. Timely transfers can arrest serious declines otherwise hard to reverse. More efficient investment decisions can be made, improving the risk and return trade-off.	Jack and Suri (2011), Aron and Muellbauer (2019)
ICT and stock-market efficiency	How does technological progress shape financial markets?	ICTs make markets more efficient	Farboodi and Veldkamp (2019), Garleanu and Pedersen (2018)
		ICTs lower trading costs and improve price informativeness	Davila and Parlatore (2016)
		ICTs reduce search and information costs and improve the informativeness of prices	Benabou and Gertner (1993)
		ICT penetration which eventually enables (in particular) under-served groups of the society to access financial markets.	Claessens et al. (2002), Kpodar & Andrianaivo (2011), Anson et al. (2013)

4 Real-world search and due diligence of asset managers

Garleanu and Pedersen (2018) have a very informative discussion of real-world search and due dilligence of asset managers that I replicate entirely here.

While the search process involves a lot of details, the main point is that the process is time consuming and costly. For instance, there exist more funds than stocks in the United States. Many of these funds might be charging high fees while investing with little or no real information, that claim to be active but in fact track the benchmark, or funds investing more in marketing than their investment process. Therefore, finding a suitable fund is not easy for investors (just like finding a cheap stock is not easy for asset managers). Here we provide an overview of the process to illustrate the significant time and cost related to the search process of finding an asset manager and doing due diligence, but a detailed description of these items is beyond the scope of the paper.

The search process for finding an asset manager is costly and time-consuming. Here are some considerations:

- Retail Investors Searching for an Asset Manager.
  - Online Search. Some retail investors search for useful information about investing online and may make their investment online. However, finding the right websites may require significant search effort and, once located, finding and understanding the right information on the website can be difficult as discussed further below.
  - Walking into a Local Branch of a Financial Institution. Retail investors may prefer to invest in person, for example, by walking into the local branch of a financial institution such as a bank, insurance provider, or investment firm. Visiting multiple financial institutions can be time consuming and confusing for retail investors.
  - Brokers and Intermediaries. Bergstresser et al. (2009) report that a large fraction of funds are sold via brokers and study the characteristics of these fund flows.
  - Choosing from Pension System Menu. Finally, retail investors get exposure to asset management through their pension systems. In defined contribution pension schemes, retail investors must search through a menu of options for their preferred fund.
- Searching for the Relevant Information
  - Fees. Choi et al. (2009) (p. 1405) find experimental evidence that "search costs for fees matter." In particular, their study "asked 730 experimental subjects to allocate $10,000 among four real S&P 500 index funds. All subjects received the funds prospectuses. To make choices incentive-compatible, subjects expected payments depended on the actual returns of their portfolios over a specified time period after the experimental session. . . . In one treatment condition, we gave subjects a one-page 'cheat sheet' that summarized the funds front-end loads and expense ratios. . . . We find that eliminating search costs for fees improved portfolio allocations."
  - Fund Objective and Skill. Choi et al. (2009) (p.1407) also find evidence that investors face search costs associated with the funds' objectives such as the meaning of an index fund. "In a second treatment condition, we distributed one page of answers to frequently asked questions (FAQs) about S&P 500 index funds. . . . When we explained what S&P 500 index funds are in the FAQ treatment, portfolio fees dropped modestly, but the statistical significance of this drop is marginal."

  - Price and Net Asset Value. In some countries, retail investors buy and sell mutual fund shares as listed shares on an exchange. In this case, a central piece of information is the relation between the share price and the mutual fund's net asset value, but investors must search for these pieces of information on different websites and often they are not synchronous.

- Understanding the Relevant Information.
  - Financial Literacy. In their study on the choice of index funds, Choi et al. (2009) (2010, p. 1405) find that "fees paid decrease with financial literacy." Simply understanding the relevant information and, in particular, the (lack of) importance of past returns is an important part of the issue.
  - Opportunity Costs. Even for financially literate investors, the non-trivial amount of time it takes to search for a good asset manager may be viewed as a significant opportunity cost given that people have other productive uses of their time and value leisure time.

The search and due-dilligence costs for institutional/richer investors are also extensive.

- Finding the Asset Manager: The Initial Meeting.
  - Search. Institutional investors often have employees in charge of external managers. These employees search for asset managers and often build up knowledge of a large network of asset managers whom they can contact. Similarly, asset managers employ business development staff who maintain relationships with investors they know and try to connect with other asset owners, although hedge funds are subject to nonsolicitation regulation preventing them from randomly contacting potential investors and advertising. This two-way search process involves a significant amount of phone calls, emails, and repeated personal meetings, often starting with meetings between the staff members dedicated to this search process and later with meetings between the asset manager's high-level portfolio managers and the asset owner's chief investment officer and board.
  - Request for Proposal. Another way for an institutional investor to find an asset manager is to issue a request for proposal (RFP), which is a document that invites asset managers to "bid" for an asset management mandate. The RFP may describe the mandate in question (e.g., $100 million of long-only U.S. large-cap equities) and all the information about the asset manager that is required.
  - Capital Introduction. Investment banks sometimes have capital introduction ("cap intro") teams as part of their prime brokerage. A cap intro team introduces institutional investors to asset managers (e.g., hedge funds) that use the bank's prime brokerage.
  - Consultants, Investment Advisors, and Placement Agents. Institutional investors often use consultants and investment advisors to find and vet investment managers that meet their needs. On the flip side, asset managers (e.g., private equity funds) sometimes use placement agents to find investors.
  - Databases. Institutional investors also get ideas regarding which asset managers to meet by looking at databases that may contain performance numbers and overall characteristics of the covered asset managers.
- Evaluating the Asset Management Firm.
  - Assets, Funds, and Investors. An asset manager's overall AUM, the distribution of assets across fund types, client types, and location.

- People. Key personnel, overall head count information, head count by major departments, and stability of senior people.
- Client Servicing. Services and information disclosed to investors, ongoing performance attribution, market updates, etc.
- History, Culture, and Ownership. Year the asset management firm was founded, how it has evolved, general investment culture, ownership of the asset management firm, and whether the portfolio managers invest in their own funds.

• Evaluating the Specific Fund.

- Terms. Fund structure (e.g., master-feeder), investment minimum, fees, high water marks, hurdle rate, other fees (e.g., operating expenses, audit fees, administrative fees, fund organizational expenses, legal fees, sales fees, salaries), transparency of positions, and exposures.
- Redemption Terms. Any fees payable, lock-ups, gating provisions, whether the investment manager can suspend redemptions or pay redemption proceeds in-kind, and other restrictions.
- Assets and Investors. Net asset value, number of investors, and whether any investors in the fund experience fee or redemption terms that differ materially from the standard ones.

• Evaluating the Investment Process.

- Track Record. Past performance and possible performance attribution.
- Instruments. Securities traded and geographical regions.
- Team. Investment personnel, experience, education, and turnover.
- Investment Thesis and Economic Reasoning. The underlying source of profit, why should the investment strategy be expected to be profitable, who takes the other side of the trade and why, and has the strategy worked historically?
- Investment Process. Analyzing the investment process and thesis is one of the most important parts of finding an asset manager. What drives the asset manager's decisions to buy and sell, what is the investment process, what data are used, how is information gathered and analyzed, what systems are used, etc.
- Portfolio Characteristics. Leverage, turnover, liquidity, typical number of positions, and position limits.
- Examples of Past Trades. What motivated these trades, how do they reflect the general investment process, and how were positions adjusted as events evolved.
- Portfolio Construction Methodology. How is the portfolio constructed, positions adjusted over time, risk measured, position limits, etc.
- Trading Methodology. Connections to broker/dealers, staffing of trading desk, whether trading desk operates 24/7, colocation on major exchanges, use of internal or external broker algorithms, etc.
- Financing of Trades. Prime broker relations and leverage.

• Evaluating Risk Management.

- Risk Management Team.Team members, independence, and authority.
- Risk Measures. Risk measures calculated, risk reports to investors, and stress tests.
- Risk Management. How is risk managed, what actions are taken when risk limits are breached, and who makes the decision.

- Due Diligence of Operational Issues and Back Office.
  - Operations Overview. Teams, functions, and segregation of duties.
  - Life cycle of a Trade. What steps does a trade make as it flows through the manager's systems. Who can move cash and how, and what controls are in place.
  - Valuation. What independent pricing sources are used, what level of portfolio manager input is there, what controls ensure accurate pricing.
  - Reconciliation. How frequently and granularly are cash and positions reconciled.
  - Client Service. Reporting frequency, transparency, and other client services/reporting.
  - Service Providers. The main service providers used and any major changes.
  - Systems. What are the major systems with possible live system demos.
  - Counterparties. Who are the main counterparties, how are they selected, and how and by whom is counterparty risk managed.
  - Asset Verification. Some large investors will ask to speak directly to the asset manager's administrator to verify that assets are valued correctly.
- Due Diligence of Compliance, Corporate Governance, and Regulatory Issues.
  - Regulators and Regulatory Reporting. Who are the regulators for the fund, summary of recent visits/interactions, and frequency of reporting.
  - Corporate Governance. Summary of policies and oversight.
  - Employee Training. Code of ethics and training.
  - Personal Trading. What is the policy, recent violations, penalty for breach.
  - Litigation. What litigation has the firm been involved with.
  - Cybersecurity. How are IT systems and networks defended and tested.

5 New information technologies make search and due diligence easier

New information technologies such as Big Data, Artificial Intelligence, and Machine Learning, have reduced the cost of storage, computation and transformation of data (Mihet and Philippon (2020)) and have facilitated search and matching, and due dilligence activities.

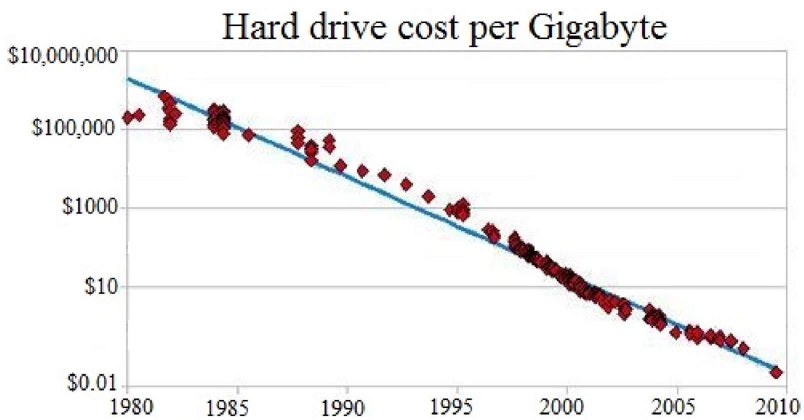


Figure 1: The price of memory hard drives over time has fallen. Source: MKomo

While the Internet of Things has had an impact for two decades now, newer information technologies have been increasing in popularity recently. Figure 2 shows that interest in these new information technologies is at an all-time high.

What sets the current digital evolution apart and could lead to qualitative changes is the combination of Big Data with Artificial Intelligence technologies to manipulate the data and extract relevant information that is then used for searching, replicating, transporting, tracking, or verification purposes. Lower search costs affect prices and price dispersion.

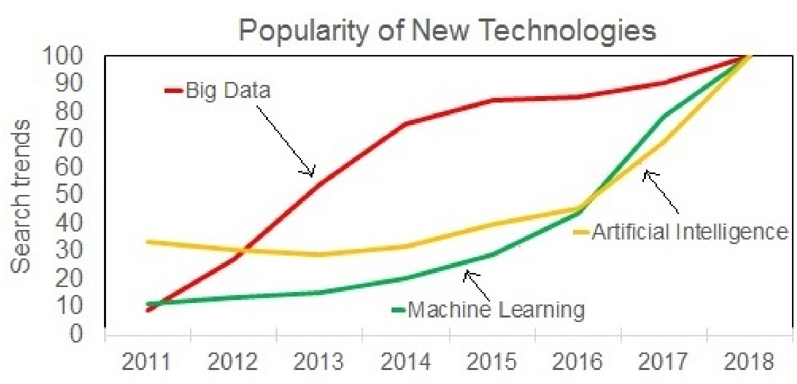


Figure 2: Numbers represent search interest relative to the highest point on the chart for the given time. A value of 100 denotes peak popularity for the term. A value of 50 means that the term is half as popular than at the highest point. Source: Google Trends

They affect product variety and media availability, They change matches in a variety of settings, from labor markets (Autor 2001), to asset markets (Barber and Odean 2001), to retail markets (Borenstein and Saloner 2001, and Bakos 2001) to marriage markets.

They have led to an increase in the prevalence of platform-based businesses and affected the organization of firms (Jullien 2012, and de Corniere 2016).

Data storage costs have also fallen over time. This allows new technologies to filter and extract more information than ever before at an ever lower cost.

Artificial intelligence, for example, is increasingly used for due dilligence purposes. It can automatically search through a host of unstructured documents and contracts and extract essential content within these documents for review.

AI works just like a human researcher - except that it sorts through documents and information remarkably faster, reducing labor and opportunity costs. While AI technology can perform more tasks in less time, it also ensures greater accuracy in reporting.

While it is harder to obtain data on the opportunity costs of time spent searching professional asset managers, there is more precise data on the other side of the market: the advertising industry. Google ads, for example, are getting cheaper and cheaper, as shown in the Figure 3.

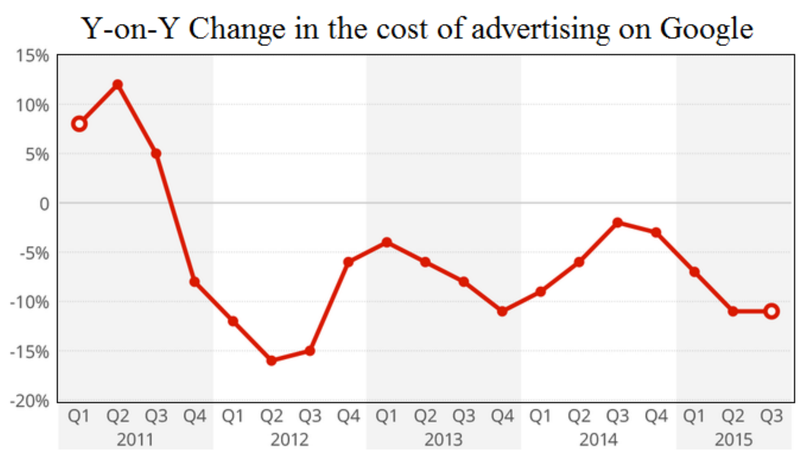


Figure 3: Year-over-year change of the average cost per click on Google ads. Source: Statista

6 Returns of hedge fund and family-owned offices

The "old-consensus" in the finance literature was that the average fund manager has no skill, but a "new consensus" has emerged that the average hides significant cross-sectional variation in manager skill among mutual funds, hedge funds, private equity and venture capital (Garleanu and Pedersen (2018)).

Indeed, there is plenty of evidence that managers of hedge funds, single family-owned offices, and multi-family-owned offices earn higher returns both before and after fees. I provide more details below.

Evidence on the risk-adjusted returns attained by hedge funds is provided by Preqin and AIMA (2018), Kosowski et al. (2007), Fung et al. (2008), Jagannathan et al. (2010), on private equity and venture capital by Kaplan and Schoar (2005), and on single and multiple family-owned offices by UBS SURVEYS.

Data from Preqin and AIMA (2018) shows that hedge funds have produced more consistent and steadier returns than equities or bonds over both the short term and the long term as shown in Table 2. Risk-adjusted returns, represented by the Sharpe ratio, reflect the volatility of the returns as well as the returns themselves. The higher the ratio, the better the risk-adjusted returns.

The risk-adjusted return as measured by the Sharpe ratio is calculated by subtracting the risk-free rate (typically the return on US treasury securities) from the fund or index performance (returns, net of fees) and dividing this by the fund or index's volatility.

The empirical analysis is based on the returns of more than 2,300 individual hedge funds that report to Preqin's All-Strategies Hedge Fund Index, an equal-weighted benchmark. Moreover, according to my own analysis of the data, about 32% of all hedge funds produced double-digit returns in 2017, up from about 23% in 2016.

Table 2: Hedge funds beat stock and bond indices on a risk-adjusted basis

Horizon	Expert advisors	S&P 500	BB global bonds
1-year	0.65	0.40	0.18
3-year	1.37	0.98	0.09
5-year	1.58	1.46	-0.24
10-year	0.73	0.41	0.13

The table shows the Sharpe ratios for hedge fund managers, the S&P 500 equity index, and the Bloomberg-Barclays global bond index. Source: Returns data from Preqin and AIMA (2018)

There is also evidence that hedge funds outperform even net of fees. Kosowski et al. (2007) (p. 2551) conclude that 'a sizeable minority of managers pick stocks well enough to more than cover their costs'.

In the model, this outperformance after fees is expected as compensation for investors' search costs, but it is still puzzling in the light of the "old-consensus" that all managers deliver zero outperformance after fees (or even negative performance after fees). Kosowski et al. (2007) add that 'top hedge fund performance cannot be explained by luck, and hedge fund performance persists at annual horizons (...)

Our results are robust and neither confined to small funds nor driven by incubation bias, backhill bias, or serial correlation.'

Data on the excess returns of family-owned offices (FO) is less systematic because these entities are not regulated and do not have to report their financial activities to regulators.

However, various market surveys of their activities suggest that FOs are active asset management companies and they make annual returns of between $17\% - 35\%$, which is much higher than any passive index (see Global Family Office Report by UBS and Campden Wealth).

Leon Cooperman, the owner of Omega Advisors and a Wall Street superstar is often quoted as saying that "The billionaires of this world have not become rich by chasing the S&P 500". According to the Economist, family-owned offices invest in high-risk, high-returns assets (consistent with the predictions of the model).

The Economist reports that 'FOs are embracing sectors as diverse and risky as cannabis, e-sports, and crypto investing'. Lastly, a significant portion of FO's portfolios consists of directly held private equity, which is totally inaccesible to poor investors.

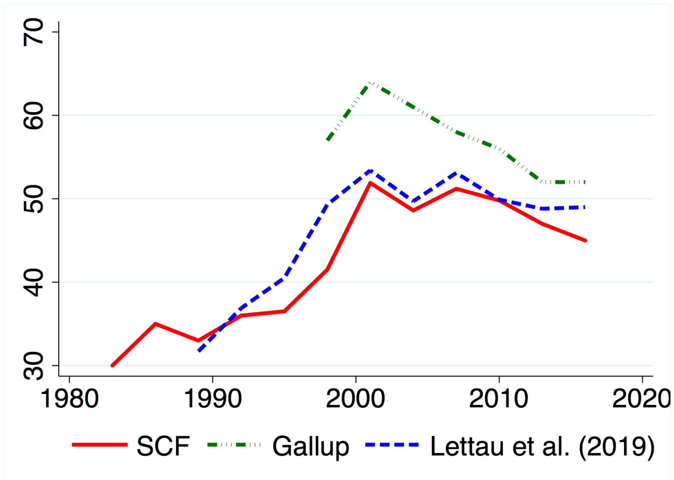
Family offices are generally established by attracting talented wealth and asset managers from mutual funds. While there is no publicly available data set detailing the positions and the returns of family-owned offices, surveys put the annual returns at an average as high as 35% per year.

The exclusive active asset management industry is subject to many frictions, however, since investors must search for informed managers able to deliver superior returns.

7 Participation

Below I plot various measures of stock-market participation. The data comes from SCF, the Gallup surveys, and Lettau et al. (2019). While the measurements differ from one series to another according to the data source, all three time-series exhibit the inverted-U shape pattern I focus on matching.

Figure 4: US Stock market participation rates from various surveys and different ways of measuring participation



8 Equity Premium Evidence

The equity premium fell before 2001, then rose with the information revolution, independently of whether it is a historical measure or an implied measure.

Figure 5: **Historical Equity Risk Premium**

Source: Morningstar.

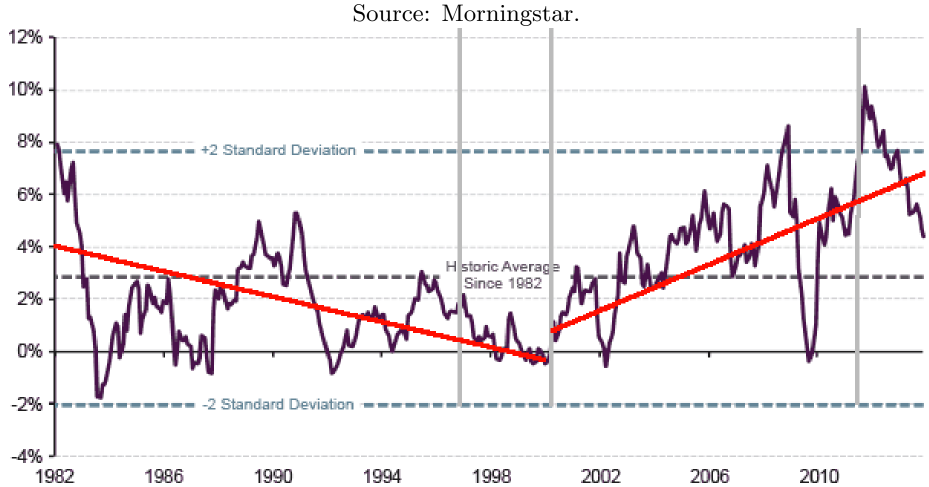


Figure 6: **Implied Equity Risk Premium, DDM method**

Source: Damodoran (2019).

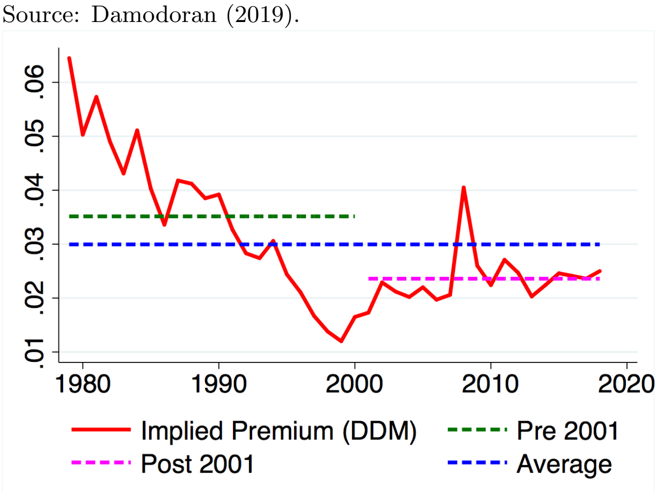
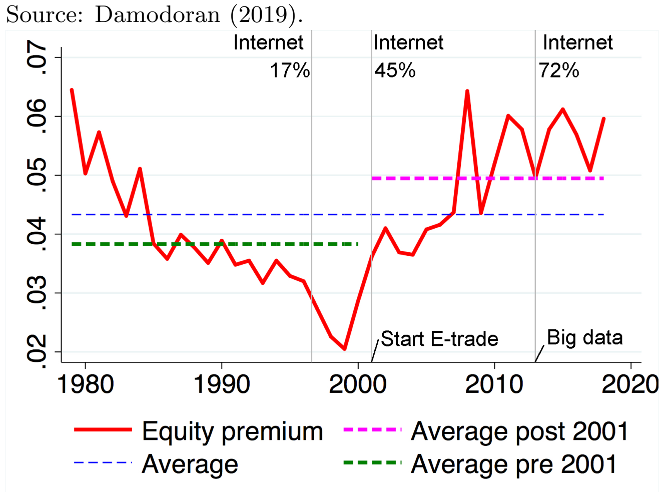


Figure 7: **Implied Equity Risk Premium, FCFE method**

Source: Damodoran (2019).



9 Price informativeness by investor size and sophistication

Data sources: I follow Bai et al. (2016) to construct measures of price informativeness from 1980-2014. I combine several firm level panel datasets, all of which are available for download on WRDS. The main sample is Compustat accounting variables. Stock prices are obtained from CRSP. Institutional ownership comes from 13-F filings that require all institutional organizations to file a report on the number of institutional owners, the number of share issued and the percentage of outstanding shares held by each institution (my key measure of institutional ownership). The GDP deflator used to adjust for inflation is from the BEA. Stock prices are taken at the end of March, and accounting variables as of the end of the previous fiscal year, typically December. This timing convention ensures that market participants have access to the accounting variables that are used as controls.

Sample selection: I consider both the entire universe of Compustat firms and the S&P500 firms. These firms represent more than 80 percent of the American equity market by capitalization, and they are large-cap companies that have been around for most of the period studied. Their characteristics have remained remarkably stable, which makes them comparable over time. In this way, I do not have to worry about composition effects (about new firms that are very volatile and hard to price entering the market). Moreover, I do not have to worry about firm size driving the effects, as these firms are all large in terms of their market-capitalization.

Measure of price informativeness: Similar to Bai et al. (2016), I correct for delisting (to ensure that the measure of price informativeness is free of survivorship bias), and for inflation (because I am interested in real price informativeness changing over time.) The main equity valuation measure is the log-ratio of market capitalization to total assets, $logM/A$. The main cash flow variable is earnings measured as EBIT. I scale EBIT by current total assets, such that $EBIT/A$. Now, in a forecasting regression for earnings with horizon $h = 1, 3$ and 5 years, the left-side variable is $EBIT_{t+h}/A_t$. To construct the measure of price informativeness, I run cross-sectional regressions of future earnings on current market prices. I include current earnings and industry sector as controls to avoid crediting markets with obvious public information. Specifically, in each year $t = 1980, ..., 2014$ and for every horizon $h = 1, 3, 5$, I run:

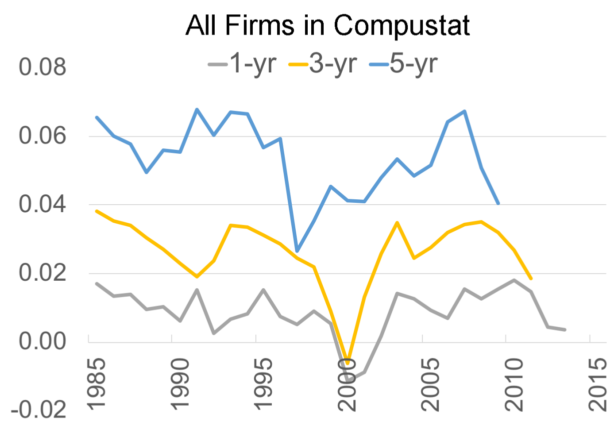
$$\frac{EBIT_{i,t+h}}{A_{i,t}} = a_{t,h} + b_{t,h} log \frac{M_{i,t}}{A_{i,t}} + c_{t,h} \frac{E_{i,t}}{A_{i,t}} + d^s_{t,h} I^s_{i,t} + \epsilon_{i,t,h}$$

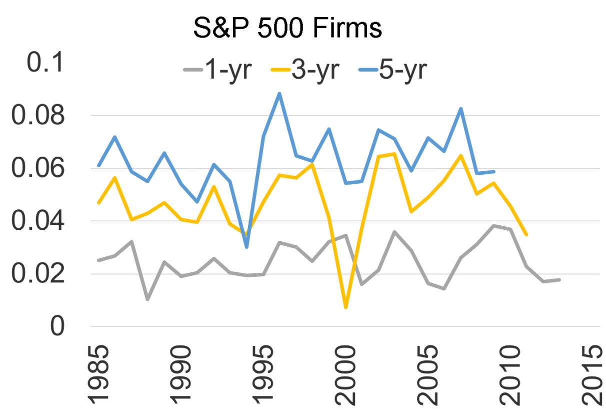
where i is the firm index and $I^s_{i,t}$ a sector (one-digit SIC code) indicator. These regressions give a set of coefficients indexed by year t and horizon h. From here, price informativeness is calculated as the predicted variance of future cash flows from market prices. I compute it here with a change of taking its square, which gives meaningful units. From the regression above, price informativeness in year t at horizon h is the forecasting coefficient $b_{t,h}$ multiplied by $\sigma_t(log(M/A))$, the cross sectional standard deviation of the forecasting variable $logM/A$ in year t. This is the measure of price informativeness over time.

$$\left(\sqrt{\mathbb{V}_{FPE}}\right)_{t,h} = b_{t,h} \times \sigma_t(log(M/A))$$

Trends over time: Plotting this trend over time for the universe of Compustat firms shows a strong U-shaped pattern of price informativeness since the 1980s. This pattern is robust across industries, even when including or excluding finance and real estate firms.

Figure 8: **Stock Price Informativeness Over Time**





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