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Institutionalization and prudence attitude in an imperfect competitive market

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ABSTRACT
Previous research has debated about whether institutionalization could improve market efficiency. We develop a theoretical model under anticipated utility combined with probability weighting to study the impacts of institutionalization on market participation and market efficiency. The prudence attitude towards probability uncertainty leads to limited participation by investors. We find that institutionalization influences the market in two different ways. An increase in the total sector size of institutional investors facilitates price discovery but discourages market participation from naïve investors due to information asymmetry. However, when the top institution has high market power, this large institution trades strategically to induce more participation by naïve traders for risk-sharing at the cost of lowering information efficiency.

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1. Introduction

The past decade has witnessed a rapid growth of institutional trading in the financial markets. In mid-2017, institutional investors possessed over 80% of the market value of all companies listed in the S&P 500. As of December 2016, the largest institutional investor had a stunning ownership of more than 6% of the total equity assets, and until the mid-2017, the 'Giant Three' index funds – Blackrock, Vanguard, and State Street – collectively had held an average stake of more than 20% of S&P 500 companies (Bebchuk and Hirst 2019; Ben-David et al. 2021). However, it is still an open question that how institutionalization influences market efficiency (Ben-David et al. 2021; Kacperczyk, Sundaresan, and Wang 2021; Koijen and Yogo 2019).

Generally, institutionalization refers to the growth of institutional investors in the financial market. But the expansion of institutional investors may have different impacts depending on how the market evolves. The market could be more efficient if there are more institutional investors with information advantages over retail traders (Bekaert and Harvey 2000; Boehmer and Kelley 2009; Kacperczyk, Sundaresan, and Wang 2021). However, if some institutional investors become dominant in the market, they might trade less aggressively due to their high price impact, which could inhibit price discovery and impair market efficiency (Ben-David et al. 2021; De Long et al. 1990; Jiao and Ye 2014; Stein 2009). Therefore, it is essential to take an insight into these co-existed effects when we analyze the influences of institutionalization. In our paper, we consider the two most prominent trends in the process of institutionalization: an increase in the total sector size and a surge in the market concentration. We develop a theoretical model to investigate how these two attributes of institutionalization affect the trading behaviors of investors and market efficiency.

In our model, there are three different types of investors: monopolistic traders, sophisticated traders, and naïve traders. The monopolistic trader and sophisticated traders represent institutional investors, while naïve

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investors act as retail investors. The most crucial feature of institutional investors in our paper is that they are not perfectly competitive. The top institutions could own a much higher market share than that of the rest institutions (Bebchuk and Hirst 2019; Ben-David et al. 2021; Kacperczyk, Nosal, and Sundaresan 2023).[1] Therefore, the top institutions could have different trading strategies from other institutions due to their large market power. In our paper, we model the top institution as the monopolistic trader who has market power and considers the price impact of her tradings. The rest institutional investors, or the sophisticated traders in our model, are competitive and do not have a price impact. The sector size of institutional investors is measured by the total market share of the monopolistic trader and the sophisticated traders, while the market concentration in institutions is assessed by the proportion of the market share of the monopolistic trader among all institutional investors. The differentiation in the type of institutional investors allows us to investigate the distinct impacts of the changes in the sector size and market concentration, the two aspects of institutionalization, separately. Another feature of institutional investors is the information advantage. Institutional investors are supposed to own superior capabilities in collecting and processing information compared to retail traders (Baik, Kang, and Kim 2010; Borochin and Yang 2017; Chen, Kelly, and Wu 2020). We assume that institutional investors and retail investors have different beliefs about the asset payoff. Specifically, institutional investors know the exact mean and the variance of the payoff, but retail investors see these parameters as random variables that follow certain distributions. This feature characterizes the different information sets of institutional investors and retail investors and enables us to explore how institutionalization changes price efficiency.

Different from the previous research on institutional investors which assumes that investors behave according to the expected utility (EU) theory (Huang, Qiu, and Yang 2020; Kacperczyk, Nosal, and Sundaresan 2023; Kyle 1985), our model considers the situation when investors make decisions based on the anticipated utility (AU) theory with probability weighting. In fact, both institutional investors and retail investors frequently violate the predictions by EU theory (An et al. 2020; Baillon et al. 2018; Blau, DeLisle, and Whitby 2020; Dimmock, Kouwenberg, and Wakker 2016). Therefore, as Peter Wakker has proposed (Wakker 2010), it is crucial to incorporate the non-EU theory in the analysis of financial markets.[2] In our paper, we assume that all traders evaluate their well-being by AU, and they do not use objective probabilities but transformed probabilities when evaluating risk. The distortion between the objective probabilities and the transformed probabilities is characterized by a concave Wang-transform probability weighting function (Wang 1996, 2000). The concavity in the probability weighting function reflects investors' tendency to overweight extremely negative outcomes and underweight extremely positive outcomes, which is called the *prudence attitude* in our paper [3]. In the financial market, prudence attitude leads to more cautious buys or sells by investors. For example, when the investor is considering a long position in a risky asset, she may undervalue the expected return of the risky asset because she underweights extremely positive outcomes and overweight extremely negative outcomes. Whereas when shorting a risky asset, she may overvalue the expected return due to the same reason. We find that investors with a prudence attitude have a piece-wise demand function which depends on the intervals of price. When asset price lies in a certain interval, the demand becomes zero, which indicates that non-participation could emerge due to prudence attitude. The participation decisions by investors also play an important role when we analyze the impacts of institutionalization. This is because investors' participation would affect liquidity and risk-sharing and ultimately influence asset pricing and market efficiency. Our model is applicable to scenarios in which the economy incorporates a majority of prudent investors who pessimistically believe the worst outcomes are more likely to occur. For example, in emerging markets or during the pandemic where participants are exposed to more uncertainty and display pessimism towards uncertainty (see a summary by Wakker (2010), Chapter 7, p.204).

This paper yields two main findings. First, although both sector size expansion and market concentration reflect the trend of institutionalization, we find that they have substantially different impacts on the cost of capital and market participation in the financial markets. Specifically, market concentration among financial institutions consistently raises the cost of capital and encourages retail traders to participate in the market. However, the sector size effect is more complex and contingent on different circumstances. In most cases, an increase in the sector size of institutional investors tends to lower the cost of capital and discourage retail investors from trading risky assets. But, if the asset has a large supply and the market is highly concentrated, we observe a U-shaped effect on price premium and market participation.

The divergent results from the sector size effect and market concentration effect are due to the conflicts between two channels – the information channel and the risk-sharing channel. Institutional investors have full information and their trading activity will drive the asset price back to its fundamental value. Therefore, the cost of capital decreases. When the top institution has market power, it could affect the price so as to induce more participation from naïve investors for risk-sharing. However, because naïve investors require a higher risk premium due to information shortage, the cost of capital increases. The above two channels lead to opposing outcomes, and the interplay of them determines the influences of sector size expansion and the concentration of market capitalization. Therefore, when the market is less concentrated, the information channel dominates when the sector size increases; whereas when the top institution owns a large market fraction, the risk-sharing channel would dominate.

Our second finding is that investors' prudence attitude provokes limited participation and price jump in equilibrium. We find that the market participants with a prudence attitude require a higher premium than in an EU model to compensate for their probability aversion. They will not trade if the premium is not sufficiently large. As a consequence, there exists a price vacuum in which the premium does not meet investors' requirements: No trade happens and no price is formed, which causes the price jump. Furthermore, our model suggests that price jumps result from shifts in asset supply, not from information shocks. This implies that price jumps could stem from fluctuations in market liquidity, independent of fundamental value changes. Thus, our paper not only offers a fresh perspective on limited market participation from the standpoint of investors' prudence attitude, but also aligns with empirical research underscoring liquidity shocks as a more significant driver of price jumps than information shocks (Jiang, Lo, and Verdelhan 2011; Jiang and Yao 2013; Scaillet, Treccani, and Trevisan 2020).

Our paper contributes to a body of economic literature studying the impacts of institutional trading on financial markets (Chiyachantana et al. 2004; De Long et al. 1990; Edelen and Warner 2001; Gompers and Metrick 2001; Kacperczyk, Sundaresan, and Wang 2021; Koijen and Yogo 2019). Decades of discussions of whether institutional trading destabilizes the financial markets have not reached a consensus. Some papers argue that institutional trading will increase market volatility and might destabilize the market (Basak and Pavlova 2013; Ben-David et al. 2021; Bremus and Buch 2017; Gabaix 2011; Gabaix et al. 2006). Other papers demonstrate that institutional trading will improve the market efficiency (Bekaert and Harvey 2000; Boehmer and Kelley 2009; He et al. 2013; Kacperczyk, Sundaresan, and Wang 2021), and find no significant evidence for the destabilizing effect (Chiyachantana et al. 2006; Sias, Turtle, and Zykaj 2016). Our paper reconciles the disagreement by suggesting that the impacts of institutionalization should be examined by the sector size effect and the market concentration effect because they work differently in financial markets.

Our paper also contributes to an extensive literature on information asymmetry. Following Grossman and Stiglitz (1980), a great number of papers study the effects of asymmetric information on market equilibrium (Easley and O'hara 2004; O'Hara 2003; Vayanos and Wang 2012). These papers focus on the expected returns and market liquidity, the asset demand of investors, and the welfare differences between market participants. Another stream of research explores information asymmetry in a general equilibrium framework and investigates agents' decision-making process and their optimal choice (Easley and O'Hara 2009, 2010; Huang, Wang, and Zhang 2021; Huang, Zhang, and Zhu 2017). However, limited research looks at individuals' sensitivity to probabilities. Intuitively, when facing asymmetric information, investors incline to trade more prudently due to their aversion towards uncertainty. We introduce an anticipated utility model with the Wang transform in this paper, which helps us look into the role of investors' prudence attitude.

Finally, our paper adds to a growing body of the literature taking institutions' market power into consideration (Kacperczyk, Nosal, and Sundaresan 2023; Liu and Wang 2016; Qiu, Wang, and Zhang 2023; Vayanos and Wang 2012). These papers have investigated how liquidity shock affects the financial market (Vayanos and Wang 2012), the impact of information asymmetry on bid-ask spreads with imperfect competitive market makers (Liu and Wang 2016), and the impacts of large, market-powered institutions on market efficiency (Kacperczyk, Nosal, and Sundaresan 2023; Qiu, Wang, and Zhang 2023). Our work provides a new angle to examine the market power of institutional investors by differentiating the impacts of institutionalization into the sector size effect and the market concentration effect. In addition, our paper features the agents' prudence attitude and endogenizes the participation decisions of all investors in an imperfect competition model.

The remainder of this paper is structured as follows. Section 2 describes the model setting, displays the demand functions of different traders, and presents the derivation of the unique Nash equilibrium of our non-competitive model. In Section 3, we discuss the sector size effect and the market concentration effect of institutionalization on market participation and asset pricing. Section 4 concludes.

2. The model

We analyze a two-period economy ($t = 0, 1$) with one risk-free asset and one risky asset. The risk-free asset, or the money, has an elastic supply and a constant price of 1.[4] The risky asset has a constant supply z, and its payoff at time 1 follows a normal distribution $v \sim N(\hat{\mu}, \hat{\sigma}^2)$.

We suppose that there are three types of agents in the economy: monopolistic traders (M), sophisticated traders (S), and naïve traders (N). All of them have CARA utility[5] for final wealth:

$$u(w) = -\mathrm{e}^{-\gamma w},$$

where γ is the risk aversion parameter. These three types of traders are different in their beliefs about the asset payoff and their price impact. To be more precise, these three types of traders have heterogeneous beliefs about the distribution of asset payoff: monopolistic and sophisticated traders have the correct belief that they know the exact values of mean $\hat{\mu}$ and standard deviation $\hat{\sigma}$ of payoff, while the naïve only recognize that both parameters are uniformly distributed on the intervals $\mu \sim U[\underline{\mu}, \overline{\mu}]$ and $\sigma \sim U[\underline{\sigma}, \overline{\sigma}]$, respectively[6]. Moreover, we assume these traders have disparate price impacts. Specifically, monopolistic traders have the market power to alter asset prices when they trade risky assets, while sophisticated and naïve traders are price-takers. Therefore, monopolistic traders represent giant institutional investors whose large orders are inclined to shift market prices. Sophisticated and naïve investors serve as small institutional investors and retail investors, respectively, who take market prices as given and submit their orders in response to the observed prices. Three types of traders constitute fractions θ_M, θ_S and θ_N in $(0, 1)$ among all the participants, where we assume that

$$\theta_M + \theta_S + \theta_N = 1.$$

The initial wealth of a typical trader is denoted as W_0.[7] Where no confusion would occur, we drop the trader index. The trader's budget constraint is

$$W_0 = m + px,$$

where m is the quantity of money, x is the quantity demand for the risky asset, and p represents the price of the risky asset. Thus, the final wealth of the agent is

$$\tilde{W} = W_0 + (v - p)x.$$

For sophisticated and naïve investors, the price p is taken as given when they make trading decisions, whereas for monopolistic traders, the price should be presented as $p(x_M)$, which reflects their impact on market price. Unlike the prevailing literature, we assume that all traders evaluate their well-being by anticipated utility (AU, Quiggin 1982) instead of the traditional expected utility (EU). Following Huang, Wang, and Zhang (2021), we assume that

$$AU(\tilde{W}) = \int_{\mathbb{R}} u(w) dg_\alpha \left(F_{\tilde{W}}(w)\right), \tag{1}$$

where

$$g_\alpha(\pi) = \Phi\left(\Phi^{-1}(\pi) + \alpha\right)$$

is the Wang transform, serving as a distortion operator, $\pi \in [0, 1]$ is a real number that represents the cumulative probability of an original objective distribution, and Φ is the standard normal cumulative distribution function. The parameter α in the Wang transform determines the convexity of the distortion function. When $\alpha > 0$,

$g_\alpha(\pi)$ is concave in π. A concave distortion function means that agents overweight the possibility of extreme events and underweight ones with high objective probability. We refer to this tendency as prudence attitude as in Huang, Wang, and Zhang (2021). The magnitude of α indicates the prudence level of an investor. When $\alpha = 0$, the anticipate utility model degenerates into an EU model.

Compared with other distortion functions, the Wang-transform distortion function, proposed by Wang (1996) and Wang (2000), has several good properties and does well in constructing coherent risk measures and pricing insurance premiums. This distortion function has been widely employed in the actuarial and insurance fields because it is computable and can properly depict the aversion attitude of market participants towards uncertainty. The Wang transform works differently from decision weight functions in the prospect theory. Kahneman and Tversky (1979) suggest an inverse-S-shaped distortion function, which portrays irrational individuals' cognitive bias. Nevertheless, in this paper, we do not explore the impacts of individuals' perceptual limitations; we are more interested in agents', especially institutional traders' sensitivity to probabilities and therefore adopt a universally concave distortion function. Moreover, our model is tractable under the Wang transform setting.

In our model, we assume that $\alpha > 0$, and all agents implement the same concave distortion to the objective probabilities, which represents their prudence attitude towards probabilistic uncertainty [8]. A prudent trader tends to overweight events that have bad outcomes while underweight best-rank events (Wakker 2010), which we believe to be the prevailing feature of market participants in the real world. Therefore, the traders' anticipated utility w.r.t. the concave Wang transform can be calculated as[9]

$$AU(\tilde{W}) = -e^{-\gamma\left[\mu_{\tilde{W}} - \alpha\sigma_{\tilde{W}} - \frac{1}{2}\gamma\sigma^2_{\tilde{W}}\right]}.$$

To simplify our model, we use the certainty equivalent of AU to represent a trader's utility. Specifically, the certainty equivalent of $\tilde{W}$ is

$$CE\left(\tilde{W}\right) = \mu_{\tilde{W}} - \alpha\sigma_{\tilde{W}} - \frac{1}{2}\gamma\sigma^2_{\tilde{W}} = W_0 + (\mu - p)x - \alpha\sigma|x| - \frac{1}{2}\gamma\sigma^2 x^2, \quad \alpha > 0 \tag{2}$$

and we have[10]

$$\max_x AU(\tilde{W}) \iff \max_x CE(\tilde{W}).$$

Compared to EU, the certainty equivalent of final wealth $\tilde{W}$ under AU has an additional term $-\alpha\sigma|x|$, which is related to the prudence parameter α, the standard deviation of the risky asset σ, and the absolute quantity of a trader's demand x. A trader with a higher prudence level (a larger α), a greater uncertainty towards the asset payoff (a higher standard deviation), or a bigger long or short position in risky assets (a larger $|x|$), tends to have lower utility. The negative impact of the trader's prudence level α on her utility mainly results from her concave distortion of the objective probabilities, as we mentioned above. Intuitively, when a trader is more prudent with a greater α, she is inclined to overweight the probability of extreme negative returns and underweight the possibility of extreme positive returns. This prudence attitude discourages the trader from holding a proper amount of risky assets by reducing the expected return of her portfolio, and also leads to a decrease in her utility.

Our model extends (Huang, Wang, and Zhang 2021) work to investigate the impacts of institutional trading on financial markets under anticipated utility via a Wang-transform distortion function. Our paper is also close to Qiu, Wang, and Zhang (2023), who study an imperfect competition market under ambiguity, and Kacperczyk, Nosal, and Sundaresan (2023), who focus on the effects of private signals and information learning on price informativeness. In our paper, however, we do not incorporate ambiguity or information revelation process; instead, we consider decision-makers' sensitivity towards probabilistic uncertainty and pay attention to the impacts of institutionalization on price premium and market participation, which will be discussed in Section 3. Here we look into the traders' optimization problems and calculate their demand functions to see how AU and the Wang transform work in agents' trading strategies.

We first consider the optimization problem of sophisticated traders. Knowing the precise distribution of asset payoff, sophisticated traders choose their strategy by maximizing the certainty equivalent of their anticipated utility

$$\max_x \; CE\left(\tilde{W}\right) = W_0 + (\hat{\mu} - p)x - \alpha\hat{\sigma}|x| - \frac{1}{2}\gamma\hat{\sigma}^2x^2. \tag{3}$$

For naïve traders, they do not know the exact value of the payoff's mean or variance. However, they believe that the mean payoff ($\hat{\mu}$) and the standard deviation ($\hat{\sigma}$) are uniformly distributed on the intervals $\mu \sim U[\underline{\mu}, \overline{\mu}]$ and $\sigma \sim U[\underline{\sigma}, \overline{\sigma}]$, respectively.[11] The optimization problem of naïve investors is equivalent to the one followed:

$$\max_x \; E\left[CE\left(\tilde{W}\right)\right] = W_0 + \left(E[\mu] - p\right)x - \alpha E[\sigma]|x| - \frac{1}{2}\gamma\Sigma^2x^2, \tag{4}$$

where $CE(\cdot)$ is the certainty equivalent operator, Σ^2 is the expected mean of variance ($E[\sigma^2]$) which is greater than the true variance $\hat{\sigma}^2$ due to uncertainty[12].

Unlike sophisticated or naïve traders who take price as given, monopolistic traders have market power that their trading activity does affect the asset price. Their demand is therefore derived from both the market clearing condition and their optimization problem. The market clearing condition is that

$$\theta_S x_S(p) + \theta_N x_N(p) + \theta_M x_M = z, \tag{5}$$

where the left-hand side of the equation represents the total demand of all investors for the risky asset, and the right-hand side, z, is the market supply of the asset.[13] Monopolistic traders take their price impact into consideration when they choose the optimal trading strategy. Thus, their optimization problem is

$$\max_x \; W_0 + \left[\hat{\mu} - p(x)\right]x - \alpha\hat{\sigma}|x| - \frac{1}{2}\gamma\hat{\sigma}^2x^2. \tag{6}$$

Given the demand of each type of traders in the market and the asset price as a function of x_M, we now come to the definition of a Nash equilibrium as follows.

Definition 2.1: An equilibrium $(x_S^*(p), x_N^*(p), (x_M^*, p^*))$ is such that

(1) given any p, optimal demand functions $x_S^*(p)$ and $x_N^*(p)$ solve sophisticated traders' Problem (3) and naïve traders' Problem (4), respectively;
(2) given $x_S^*(p)$ and $x_N^*(p)$, p^* solves monopolistic traders' Problem (6)

$$\max_x \; W_0 + \left[\hat{\mu} - p(x)\right]x - \alpha\hat{\sigma}|x| - \frac{1}{2}\gamma\hat{\sigma}^2x^2$$

subject to the market-clearing condition (5)[14]

$$\theta_S x_S^*(p) + \theta_N x_N^*(p) + \theta_M x_M = z.$$

Next, we solve the equilibrium price and traders' equilibrium positions in closed form.

Given the price of the risky asset p and sophisticated traders' optimization problem (3), we can derive their demand function as follows:

$$x_S = \begin{cases} \dfrac{\hat{\mu} - p - \alpha\hat{\sigma}}{\gamma\hat{\sigma}^2}, & \text{for } p < \hat{\mu} - \alpha\hat{\sigma}, \\ 0, & \text{for } \hat{\mu} - \alpha\hat{\sigma} \leqslant p \leqslant \hat{\mu} + \alpha\hat{\sigma}, \\ \dfrac{\hat{\mu} - p + \alpha\hat{\sigma}}{\gamma\hat{\sigma}^2}, & \text{for } \hat{\mu} + \alpha\hat{\sigma} < p. \end{cases} \tag{7}$$

Equation (7) shows that sophisticated traders have a piece-linear demand function. Compared to the demand function in an EU model ($\alpha = 0$), a prudent sophisticated trader tends to hold a smaller position in the risky asset, indicated by the extra term $\pm\,\alpha\hat{\sigma}$ in the numerator. When the trader takes a long/short position in the asset (when $p < \hat{\mu} - \alpha\hat{\sigma}$/when $\hat{\mu} + \alpha\hat{\sigma} < p$), the absolute position is lower than that in the EU model. Moreover, she requires an extra premium $\alpha\hat{\sigma}$ to compensate for her aversion towards probabilistic uncertainty, as shown by the breakpoints of the demand function. Therefore, they would buy if the price were higher than the expected mean $\hat{\mu}$ plus the extra premium $\alpha\hat{\sigma}$ and sell if the price were lower than the expected mean minus the extra premium. If the price were in between, the investors would not trade. Thus, no participation arises when investors are prudent[15]. The price gap between the thresholds of participation is increasing with the prudence attitude measure α and the uncertainty of payoff $\hat{\sigma}$. Besides, they also trade less aggressively than in the EU model. When investors are more prudent or uncertain about the payoff, they demand less for the risky asset.

Previous literature attributes limited participation to agents' ambiguity aversion (Cao, Wang, and Zhang 2005; Easley and O'Hara 2009, 2010; Epstein and Schneider 2007, 2008; Huang, Zhang, and Zhu 2017; Illeditsch, Ganguli, and Condie 2021). Our model implies that aversion towards ambiguity is not a necessary condition for limited participation. Agents' prudence attitude also causes them to choose a pessimistic strategy and not always trade under an AU framework (Huang, Wang, and Zhang 2021).

Similarly, by solving naïve traders' optimization problem (4) given the asset price p, we are able to obtain their demand function:

$$x_N = \begin{cases} \dfrac{E[\mu] - p - \alpha E[\sigma]}{\gamma \Sigma^2}, & \text{for } p < E[\mu] - \alpha E[\sigma], \\ 0, & \text{for } E[\mu] - \alpha E[\sigma] \leqslant p \leqslant E[\mu] + \alpha E[\sigma], \\ \dfrac{E[\mu] - p + \alpha E[\sigma]}{\gamma \Sigma^2}, & \text{for } E[\mu] + \alpha E[\sigma] < p, \end{cases} \tag{8}$$

where we assume that the asset return variance perceived by naïve traders Σ^2 is greater than the real variance $\hat{\sigma}^2$.[16]

The demand function of the naïve traders is similar to that of the sophisticated traders except that naïve traders ask for a higher compensation for their information shortage. Limited participation also exists among naïve traders. Besides, because the naïve investors do not know the exact value of payoff mean or variance, they face more uncertainty and require a higher premium than do sophisticated investors. Therefore, the premium required by the naïve includes the compensations for their aversion towards probabilistic uncertainty, as shown by the term $\pm\,\alpha E(\sigma)$ in the breakpoints, and the ones for their information shortage. We assume that the parameters satisfy that $E[\mu] - \alpha E[\sigma] < \hat{\mu} - \alpha\hat{\sigma}$ and $E[\mu] + \alpha E[\sigma] > \hat{\mu} + \alpha\hat{\sigma}$. Given this assumption and $\Sigma^2 > \hat{\sigma}^2$, we can discover that naïve investors trade less than sophisticated investors.

Monopolistic traders, like sophisticated investors, they also have the correct belief about the market. However, their optimal demand is no longer obtained by solving the maximization problem under the asset price; instead, their demand and the market price are determined simultaneously. This is because monopolistic traders are those who have market power to affect asset price. When they make decisions, they take their price impact into account, hence the price is in fact a function of monopolistic traders' demand, $p(x_M)$. Therefore, to derive their optimal demand, we can first deduce the price impact of monopolistic traders, and then solve their optimization problem under $p(x_M)$. Substituting Equations (7) and (8) into the market clearing condition (5) yields the price as a function of monopolistic traders' quantity demand for the risky asset (x_M):

$$p(x_M) = \begin{cases} \hat{\mu} - \alpha\hat{\sigma} - \dfrac{\gamma}{\dfrac{\theta_S}{\hat{\sigma}^2} + \dfrac{\theta_N}{\Sigma^2}} \left(\theta_N \dfrac{\hat{\sigma}^2}{\Sigma^2} \bar{z} + z - \theta_M x_M \right), & \text{for } x_M < \dfrac{z - \theta_S \bar{z}}{\theta_M}, \\ \hat{\mu} - \alpha\hat{\sigma} + \dfrac{\gamma \hat{\sigma}^2}{\theta_S} (\theta_M x_M - z), & \text{for } \dfrac{z - \theta_S \bar{z}}{\theta_M} \leqslant x_M < \dfrac{z}{\theta_M}, \\ \hat{\mu} + \alpha\hat{\sigma} + \dfrac{\gamma \hat{\sigma}^2}{\theta_S} (\theta_M x_M - z), & \text{for } \dfrac{z}{\theta_M} < x_M \leqslant \dfrac{z - \theta_S \underline{z}}{\theta_M}, \\ \hat{\mu} + \alpha\hat{\sigma} - \dfrac{\gamma}{\dfrac{\theta_S}{\hat{\sigma}^2} + \dfrac{\theta_N}{\Sigma^2}} \left(\theta_N \dfrac{\hat{\sigma}^2}{\Sigma^2} \underline{z} + z - \theta_M x_M \right), & \text{for } \dfrac{z - \theta_S \underline{z}}{\theta_M} < x_M, \end{cases} \tag{9}$$

where $\overline{z} = \frac{(\hat{\mu}-\alpha\hat{\sigma})-(E[\mu]-\alpha E[\sigma])}{\gamma\hat{\sigma}^2} > 0$ and $\underline{z} = \frac{(\hat{\mu}+\alpha\hat{\sigma})-(E[\mu]+\alpha E[\sigma])}{\gamma\hat{\sigma}^2} < 0$. The price impact of monopolistic traders can be measured by the derivative $p'(x_M) \equiv \frac{dp(x_M)}{dx_M}$:

$$p'(x_M) = \begin{cases} \dfrac{\gamma\theta_M}{\dfrac{\theta_S}{\hat{\sigma}^2} + \dfrac{\theta_N}{\Sigma^2}}, & \text{for } x_M < \dfrac{z - \theta_S\overline{z}}{\theta_M}, \\ \dfrac{\gamma\hat{\sigma}^2\theta_M}{\theta_S}, & \text{for } \dfrac{z - \theta_S\overline{z}}{\theta_M} \leqslant x_M < \dfrac{z}{\theta_M} \text{ or } \dfrac{z}{\theta_M} < x_M \leqslant \dfrac{z - \theta_S\underline{z}}{\theta_M}, \\ \dfrac{\gamma\theta_M}{\dfrac{\theta_S}{\hat{\sigma}^2} + \dfrac{\theta_N}{\Sigma^2}}, & \text{for } \dfrac{z - \theta_S\underline{z}}{\theta_M} < x_M, \end{cases} \quad (10)$$

Equation (9) shows that the asset price is monotonically increasing with x_M. The monopolistic traders' demands have a positive price impact. And Equation (10) tells that the price impact is not a constant but varies with different x_M. It becomes greater when naïve traders do not trade because there are less investors to share the risk. Moreover, an increase in the proportion of monopolistic traders will also raise the price impact.

Then, the first-order condition (FOC) is

$$x_M = \frac{\hat{\mu} - p(x_M) - \alpha\hat{\sigma}\cdot\text{sign}(x_M)}{p'(x_M) + \gamma\hat{\sigma}^2}. \quad (11)$$

Substituting Equations (9) and (10) into (11), we obtain the optimal demand of the monopolistic traders as follows:

$$x_M = \begin{cases} \dfrac{z + \theta_N\dfrac{\hat{\sigma}^2}{\Sigma^2}\underline{z}}{\theta_S + 2\theta_M + \theta_N\dfrac{\hat{\sigma}^2}{\Sigma^2}}, & \text{for } z < \dfrac{\theta_S\theta_M + (\theta_S+\theta_M)\left(\theta_S + \theta_N\dfrac{\hat{\sigma}^2}{\Sigma^2}\right)}{\theta_S + \theta_M + \theta_N\dfrac{\hat{\sigma}^2}{\Sigma^2}}\underline{z}, \\ \dfrac{z - \theta_S\underline{z}}{\theta_M}, & \text{for } \dfrac{\theta_S\theta_M + (\theta_S+\theta_M)\left(\theta_S + \theta_N\dfrac{\hat{\sigma}^2}{\Sigma^2}\right)}{\theta_S + \theta_M + \theta_N\dfrac{\hat{\sigma}^2}{\Sigma^2}}\underline{z} \leqslant z < \dfrac{\theta_S\theta_M + (\theta_S+\theta_M)\theta_S}{\theta_S+\theta_M}\underline{z}, \\ \dfrac{z}{\theta_S + 2\theta_M}, & \text{for } \dfrac{\theta_S\theta_M + (\theta_S+\theta_M)\theta_S}{\theta_S+\theta_M}\underline{z} \leqslant z \leqslant \dfrac{\theta_S\theta_M + (\theta_S+\theta_M)\theta_S}{\theta_S+\theta_M}\overline{z}, \\ \dfrac{z - \theta_S\overline{z}}{\theta_M}, & \text{for } \dfrac{\theta_S\theta_M + (\theta_S+\theta_M)\theta_S}{\theta_S+\theta_M}\overline{z} < z \leqslant \dfrac{\theta_S\theta_M + (\theta_S+\theta_M)\left(\theta_S + \theta_N\dfrac{\hat{\sigma}^2}{\Sigma^2}\right)}{\theta_S + \theta_M + \theta_N\dfrac{\hat{\sigma}^2}{\Sigma^2}}\overline{z}, \\ \dfrac{z + \theta_N\dfrac{\hat{\sigma}^2}{\Sigma^2}\overline{z}}{\theta_S + 2\theta_M + \theta_N\dfrac{\hat{\sigma}^2}{\Sigma^2}}, & \text{for } \dfrac{\theta_S\theta_M + (\theta_S+\theta_M)\left(\theta_S + \theta_N\dfrac{\hat{\sigma}^2}{\Sigma^2}\right)}{\theta_S + \theta_M + \theta_N\dfrac{\hat{\sigma}^2}{\Sigma^2}}\overline{z} < z, \end{cases} \quad (12)$$

where $\overline{z} = \frac{(\hat{\mu}-\alpha\hat{\sigma})-(E[\mu]-\alpha E[\sigma])}{\gamma\hat{\sigma}^2} > 0$ and $\underline{z} = \frac{(\hat{\mu}+\alpha\hat{\sigma})-(E[\mu]+\alpha E[\sigma])}{\gamma\hat{\sigma}^2} < 0$, and the impacts of α on x_M are incorporated in these two terms.

Equation (12) shows that the demand function is piece-wise linear. Compared to those of sophisticated and naïve traders as in Equations (7) and (8), the demand function of monopolistic traders is not a function of the market price, but changes with the risky asset supply. As the supply of the risky asset changes, monopolistic traders have five different trading strategies correspondingly. The kinks of their demand function appear because of the adjustments of demand sensitivity to asset supply, which result from the non-participation of naïve traders. We notice that as the proportion of monopolistic traders (θ_M) grows, their optimal demand and the marginal demand ($\partial x_M/\partial z$) decrease accordingly in all cases due to greater price impact. Normally, monopolistic investors trade less without the participation of naïve investors. However, we find that in the scenarios where naïve traders do not trade (Case 2 and Case 4), monopolistic traders still trade more aggressively than in full-participation scenarios despite high price impact. This is because monopolistic traders need to absorb more risk to keep their cost of capital low. In this sense, their prudence level need not necessarily to have monotonic impacts on x_M, because their trading is more likely to be driven by their role to clear the market.

Information asymmetry plays an important role in the demand of monopolistic traders. The information asymmetry is measured by the term $\hat{\sigma}^2/\Sigma^2$, the ratio of the correct belief about payoff variance to the conceived variance by naïve investors.[17] As $\hat{\sigma}^2/\Sigma^2$ converges to 1, the information asymmetry diminishes; on the contrary, as $\hat{\sigma}^2/\Sigma^2$ gets close to zero, there is an infinite asymmetry in information. As presented in Case 1 and Case 5 in Equation (12), the marginal demand of monopolistic traders increases with information asymmetry. The severe asymmetry makes naïve traders trade more cautiously, thus leaving more risks to other investors, including monopolistic traders.

Theorem 2.1 lists the equilibrium price in each scenario.

Theorem 2.1: *When monopolistic traders have price impact, the imperfect competition market achieves a unique market equilibrium. It is one of the following seven possible scenarios*[18]*:*

(1) *If* $z < \frac{\theta_S\theta_M+(\theta_S+\theta_M)(\theta_S+\theta_N\frac{\hat{\sigma}^2}{\Sigma^2})}{\theta_S+\theta_M+\theta_N\frac{\hat{\sigma}^2}{\Sigma^2}}\underline{z}$, *the equilibrium price is*

$$p = \hat{\mu} + \alpha\hat{\sigma} - \frac{\gamma\hat{\sigma}^2\left(\theta_N\frac{\hat{\sigma}^2}{\Sigma^2}\underline{z} + z\right)}{\theta_S + \theta_M + \theta_N\frac{\hat{\sigma}^2}{\Sigma^2} - \frac{\theta_M^2}{\theta_S+\theta_M+\theta_N\frac{\hat{\sigma}^2}{\Sigma^2}}}. \tag{13}$$

(2) *If* $\frac{\theta_S\theta_M+(\theta_S+\theta_M)(\theta_S+\theta_N\frac{\hat{\sigma}^2}{\Sigma^2})}{\theta_S+\theta_M+\theta_N\frac{\hat{\sigma}^2}{\Sigma^2}}\underline{z} \leqslant z < \frac{\theta_S\theta_M+(\theta_S+\theta_M)\theta_S}{\theta_S+\theta_M}\underline{z}$, *the equilibrium price is*

$$p = E[\mu] + \alpha E[\sigma]. \tag{14}$$

(3) *If* $\frac{\theta_S\theta_M+(\theta_S+\theta_M)\theta_S}{\theta_S+\theta_M}\underline{z} \leqslant z < 0$, *the equilibrium price is*

$$p = \hat{\mu} + \alpha\hat{\sigma} - \frac{\gamma\hat{\sigma}^2 z}{\theta_S + \theta_M - \frac{\theta_M^2}{\theta_S+\theta_M}}. \tag{15}$$

(4) *If the supply of the risky asset is zero,* $z = 0$*, no trader takes a position on the risky asset and the price jumps.*

(5) *If* $0 < z \leqslant \frac{\theta_S\theta_M+(\theta_S+\theta_M)\theta_S}{\theta_S+\theta_M}\overline{z}$, *the equilibrium price is*

$$p = \hat{\mu} - \alpha\hat{\sigma} - \frac{\gamma\hat{\sigma}^2 z}{\theta_S + \theta_M - \frac{\theta_M^2}{\theta_S+\theta_M}}. \tag{16}$$

(6) *If* $\frac{\theta_S\theta_M+(\theta_S+\theta_M)\theta_S}{\theta_S+\theta_M}\overline{z} < z \leqslant \frac{\theta_S\theta_M+(\theta_S+\theta_M)(\theta_S+\theta_N\frac{\hat{\sigma}^2}{\Sigma^2})}{\theta_S+\theta_M+\theta_N\frac{\hat{\sigma}^2}{\Sigma^2}}\overline{z}$, *the equilibrium price is*

$$p = E[\mu] - \alpha E[\sigma]. \tag{17}$$

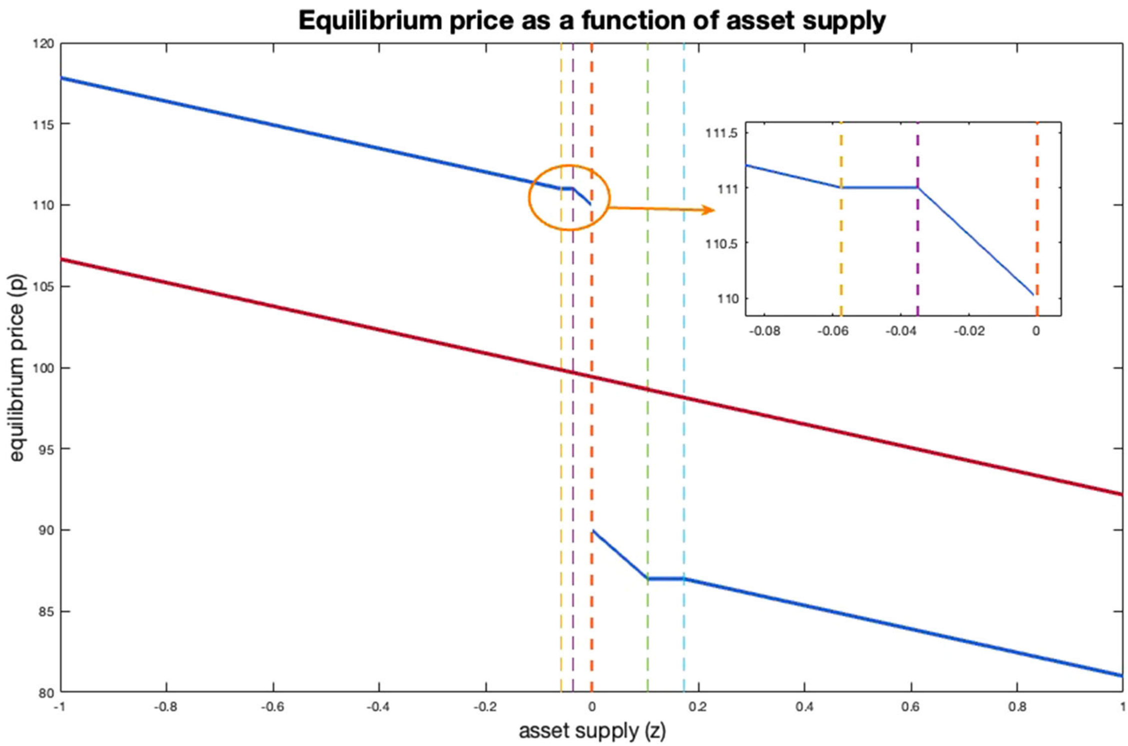


Figure 1. Price as a function of asset supply.

(7) *If* $\frac{\theta_S\theta_M+(\theta_S+\theta_M)(\theta_S+\theta_N\frac{\hat{\sigma}^2}{\Sigma^2})}{\theta_S+\theta_M+\theta_N\frac{\hat{\sigma}^2}{\Sigma^2}}\bar{z} < z$, *the equilibrium price is*

$$p = \hat{\mu} - \alpha\hat{\sigma} - \frac{\gamma\hat{\sigma}^2\left(\theta_N\frac{\hat{\sigma}^2}{\Sigma^2}\bar{z}+z\right)}{\theta_S+\theta_M+\theta_N\frac{\hat{\sigma}^2}{\Sigma^2}-\frac{\theta_M^2}{\theta_S+\theta_M+\theta_N\frac{\hat{\sigma}^2}{\Sigma^2}}}. \tag{18}$$

Theorem 2.1 shows the unique equilibrium in this imperfect competitive market. We plot the equilibrium price and the positions of different traders in Figures 1 and 2, respectively. From both Theorem 2.1 and the figures, we find that there are seven possible equilibrium scenarios, and the exogenous asset supply eventually determines the scenario. We also discover that both the sophisticated and the naïve investors trade in the same direction as the monopolistic investors[19]. Furthermore, the sophisticated even hold more (in absolute quantities) and trade more aggressively than monopolistic traders. The reason is that though the sophisticated and the monopolistic traders have the same information about asset payoff, the monopolistic will trade cautiously due to their price impact.

Moreover, there exist some ‘flat ranges’ in the equilibrium price and the corresponding equilibrium positions of both price-takers. To be more precise, in Scenarios 2 and 6, the price is irrelevant to the change of asset supply, and as a consequence, the demands of price-takers are insensitive to the changing supply as well. However, the corresponding demand sensitivity of monopolistic traders rises. We ascribe this ‘flat-price’ range to the tradeoff faced by the monopolistic traders. Take positive asset supply as an example [20]. As asset supply grows, the ‘flat range’ starts from the breakpoint at which naïve traders become willing to enter the market. Specifically, an increasing supply of the risky asset brings more risk into the market. Here comes a tradeoff for monopolistic traders. On the one hand, they hope that more traders participate in the market to share the risk with them; on

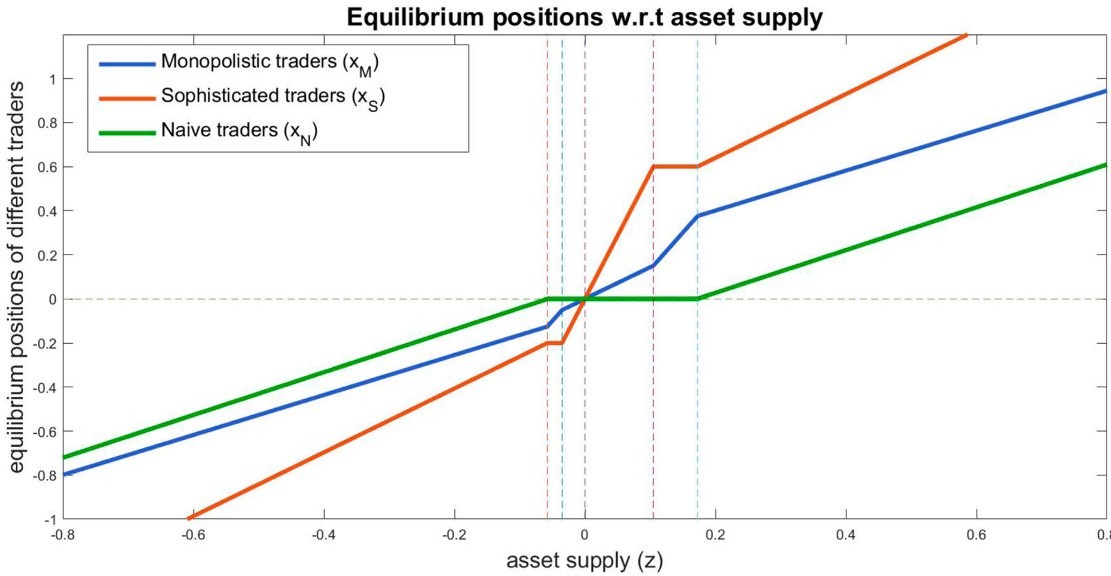


Figure 2. Equilibrium positions of different traders as functions of asset supply.

the other hand, the premium is going up to compensate the entrants for their risk-sharing, and the monopolistic traders face a higher cost of capital. If the cost-of-capital effect outweighs the risk-sharing effect, the monopolistic traders will take the extra risk by themselves rather than allow for the entrance of naïve traders. That is why we observe a 'flat range' in price and in the positions of sophisticated and naïve traders, but a steeper demand of monopolistic traders for the risky asset.

Some other appealing phenomena are also found in the equilibrium and are summarized in the following two remarks.

Remark 2.1 (Traders exhibit the 'limited-participation' trading behavior): In scenarios where the risky asset has medium or small supply, the naïve traders decide not to participate in the market. The information shortage and agents' prudence attitude together lead to the appearance of the 'limited-participation' phenomenon. Unlike the sophisticated or monopolistic traders, the naïve do not have complete information about asset payoff and merely know the distribution of its mean and variance. Therefore, naïve traders require a higher premium to compensate for their risk-sharing behavior. When the risky asset has a small or medium supply, the premium is low due to fewer risks to be shared. As a consequence, the less-sophisticated traders are kept from the market by this unappealing premium. Moreover, naïve traders' aversion towards probabilistic uncertainty plays a role in the occurrence of limited participation. A prudent trader tends to trade more pessimistically than traditional EU traders [21]. As we discussed above, under AU framework, there are limited-participation regions in the demand functions of prudent agents, even without the impact of ambiguity.

Remark 2.2 (There is a jump in the equilibrium price): We find that there exists a price jump in the equilibrium price, as is explicitly shown in Figure 1. In our model, the occurrence of the price jump is primarily due to the prudence attitude. In Figure 1, the red solid line presents the equilibrium price in an EU model, where all traders have a $\alpha = 0$. The price is a smooth and continuous function decreasing in the asset supply z. In contrast with the EU model, when prudent traders have a positive α, they ask for an extra positive premium to compensate for their aversion attitude in the long or short position, hence we find that the blue line lies above the red line when the asset has a negative supply while it locates beneath the red line when $z > 0$. As a consequence, when all traders turn their long positions to short positions, the price jump arises. In our model, the position change is due to the variation in asset supply, which can be regarded as a supply shock, or equivalently, a negative demand shock. It is worth noting that the jump arises at the critical point where the positive (negative) supply shock abruptly turns into negative (positive). Besides, as investors become more prudent, the price jump will be larger.

3. The impacts of institutionalization

In this section, we examine the effects of institutionalization on market efficiency, especially on market participation and the cost of capital. Our analysis centers on two primary dimensions of institutionalization: the sector size effect and the market concentration effect. We discuss their respective impacts and provide some empirical implications.

3.1. Institutionalization and market participation

In our model, the participation decision by naïve investors is contingent on asset prices due to prudence attitude. This framework endogenizes market participation, facilitating the comparative analysis of how institutional factors impact market participation. Furthermore, Theorem 2.1 has shown that the risky asset's price is determined by the supply of the risky asset, denoted as z. Therefore, whether naïve investors participate or not would depend on the value of z. Accordingly, we define the range of z values in which naïve investors do not trade ($x_N = 0$) as the 'non-participation range.' An expansion of the non-participation range implies that naïve investors are less likely to participate in the market. According to Theorem 2.1, this non-participation range is defined as follows:

$$\text{Non} - \text{participation range} \equiv \frac{2\alpha}{\gamma}\left[\frac{\theta_S\theta_M + (\theta_S + \theta_M)\left(\theta_S + \theta_N\frac{\hat{\sigma}^2}{\Sigma^2}\right)}{\theta_S + \theta_M + \theta_N\frac{\hat{\sigma}^2}{\Sigma^2}}\right]\left(\frac{E[\sigma] - \hat{\sigma}}{\hat{\sigma}^2}\right) \tag{19}$$

From Equation (19), our first observation is that the non-participation range correlates positively with the prudence parameter α. This suggests that as naïve investors exhibit greater prudence, their likelihood of market participation diminishes.

We identify two distinct institutionalization impacts on market participation: the sector size effect and the market concentration effect. The former denotes the proliferation of the overall market share held by institutional investors, whereas the latter refers to the trend where market share becomes increasingly concentrated among leading financial institutions. Our model assumes two different types of institutional investors: the monopolistic investor with market power, and the sophisticated investors without. This distinction allows for an isolated analysis of both the sector size effect and the market concentration effect separately.

Specifically, we quantify the sector size of institutional investors as the combined market share of both monopolistic and sophisticated traders, defined as:

$$\theta_{SM} \equiv \theta_S + \theta_M. \tag{20}$$

The market concentration level is expressed as the ratio of the market share held by monopolistic traders to the total sector size of institutional investors, represented as:

$$\zeta \equiv \frac{\theta_M}{\theta_S + \theta_M} = \frac{\theta_M}{\theta_{SM}}. \tag{21}$$

When assessing the sector size effect, alternations are confined to θ_{SM}, keeping ζ consistent. Conversely, in our analysis of the market concentration effect, we permit variations solely in ζ while maintaining θ_{SM} constant. This approach ensures a focused examination of the sector size and market concentration effects. Proposition 3.1 demonstrates the influences of the sector size effect and market concentration effect on market participation.

Proposition 3.1: *An elevation in market concentration consistently encourages market participation. However, the growth of the institutional sector's size yields divergent outcomes on market participation, contingent on market concentration levels. Specifically:*

- *In scenarios of low market concentration (low ζ), an expanding institutional sector diminishes the market participation by naïve investors.*
- *Under high market concentration (high ζ), the expansion of the sector size exhibits a U-shaped impact on the participation of naïve investors.*

Proof: The proof is in the Appendix. ■

Proposition 3.1 tells that the sector size effect and market concentration effect exert different influences on market participation. As institutional investors become less competitive, naïve investors are more likely to participate in the market. Intuitively, when market share is predominantly held by large financial institutions, they would adjust their trading strategies to mitigate the impact on asset prices. Considering their price impact, the monopolistic prefer an increased number of market participants for risk-sharing. Consequently, monopolistic traders are inclined to facilitate the entry of naïve investors into the market through their price impact, thereby enhancing market participation. In contrast, the growth of the institutional sector's size has inconsistent effects on market participation. The sector size effect's influence is contingent on the prevailing level of market concentration, ζ. When the market concentration level is low, an increasing size of institutional investors will enlarge the non-participation range of naïve investors. When the market concentration level is very high, the non-participation range exhibits an inverse-U shape as θ_{SM} grows. Figure 3 illustrates the different patterns of market concentration and sector size effect on market participation. The differential impacts of the size effect are attributable to the interplay between the information and risk-sharing channels, which exert opposing influences on market equilibrium. The information channel refers to the alteration in investors' demand due to the distribution of information, whereas the risk-sharing channel relates to the adjustment in trading behavior driven by risk-sharing motives. In our model, naïve traders lack precise knowledge of the risky asset's mean and variance, in contrast to both monopolistic and sophisticated investors. As the institutional sector expands, the naïve traders become reluctant to participate due to information shortage. Thus, the sector size effect reduces market participation via the information channel. Among institutional investors, the monopolistic trader considers their price impact and thus has the incentive to induce more market participation for risk-sharing. Consequently, an increase in the sector size of institutional investors, with a constant market concentration level, elevates the market share of monopolistic traders, thereby intensifying their risk-sharing requirements and boosting market participation. The predominant influence of the sector size effect on market participation thus varies, depending on which channel – informational or risk-sharing - prevails. For instance, in markets with low concentration, the information channel supersedes the risk-sharing motives, leading to a diminished participation. In contrast, in highly concentrated markets, the intensifying risk-sharing needs override the informational impacts, resulting in a U-shaped pattern as a function of sector size.

3.2. Institutionalization and cost of capital

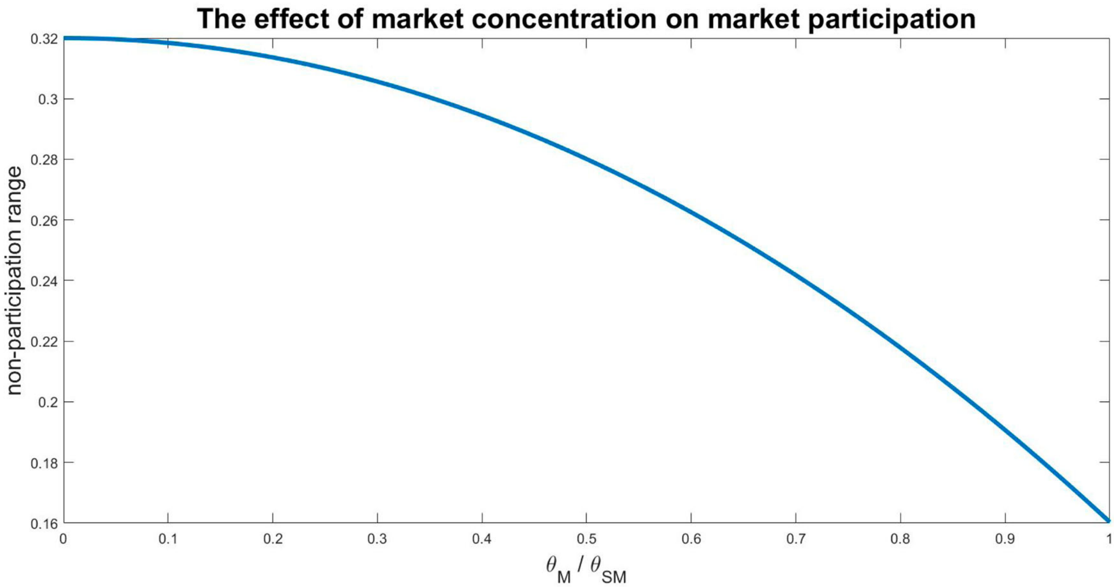
This part examines the impact on cost of capital, a pivotal variable in market efficiency. We define the cost of capital as the difference between the expected mean and the price of the risky asset:

$$\text{Cost of capital} = |\hat{\mu} - p|. \tag{22}$$

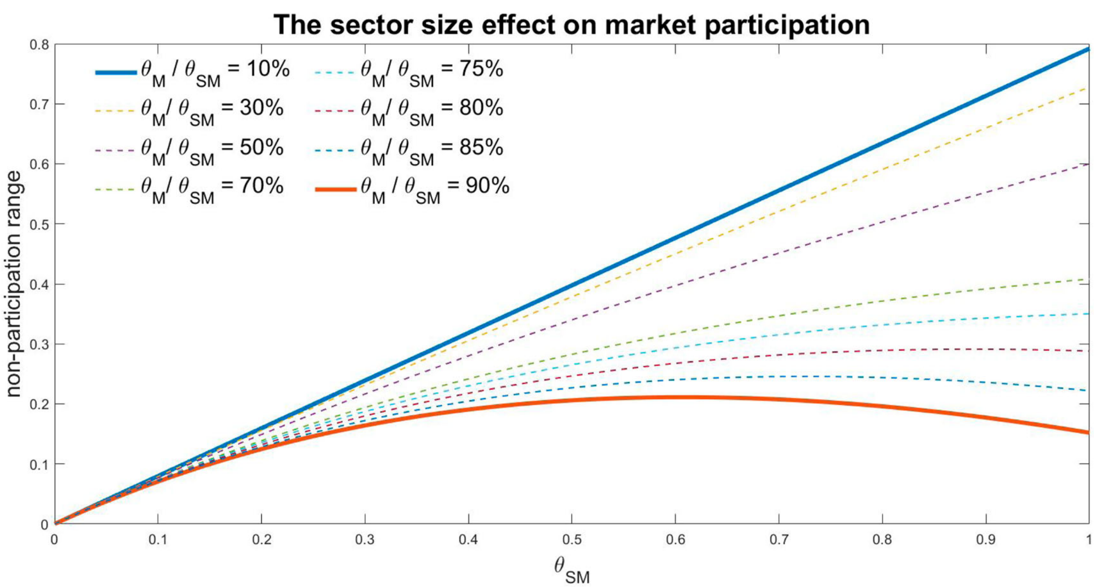
In Theorem 2.1, the equilibrium price is a piece-wise function of the risky asset's supply z. Consequently, our discussion of the cost of capital is dependent on the varying ranges of asset supply z.

We first explore the influence of prudence attitude on the cost of capital. Given the equilibrium price in Theorem 2.1 and the definition of cost of capital in Equation (22), it becomes evident that the cost of capital increases with α across all scenarios. This is because when investors are more prudent, they become more cautious and less likely to trade the risky asset. Therefore, investors would require a greater compensation for holding a risky asset, leading to a higher cost of capital.

Similar to the analysis of market participation, we also consider both the market concentration effect and sector size effect and investigate their impacts on the cost of capital. Proposition 3.2 summarizes these findings.



(a) Panel A



(b) Panel B

Figure 3. The impacts of market concentration effect and sector size effect on market participation (a,b).

Proposition 3.2: *A surge in market concentration monotonically raises the cost of capital. However, an expanding sector size exerts non-linear impacts on the cost of capital. Specifically:*

- *When the absolute asset supply ($|z|$) is sufficiently large and the market is less concentrated (low ζ), the growing size monotonically lowers the cost of capital.*

- *When the absolute asset supply ($|z|$) is sufficiently large and the market is highly concentrated (high ζ), the increasing size has a U-shaped effect: it initially reduces, then subsequently increases the cost of capital.*
- *When the absolute asset supply ($|z|$) is sufficiently small, an increasing sector size reduces the cost of capital.*

Proof: The proof is in the Appendix. ■

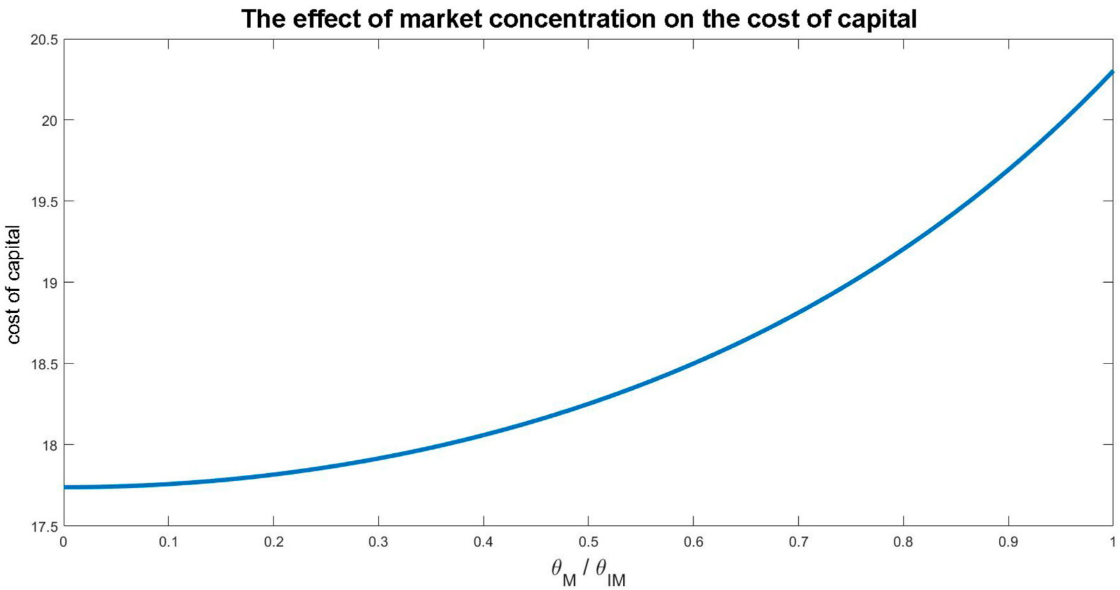
Figure 4 shows the different patterns of market concentration and sector size effect on cost of capital. As market concentration level increases, the cost of capital rises as well. This is attributed to the increased participation of naïve investors who demand higher returns for holding risky assets. Similar to the findings on market participation, the sector size effect on the cost of capital exhibits varied impacts contingent upon the level of market concentration. Additionally, given the equilibrium price is contingent on the asset supply z, the range of z emerges as a critical factor in this analysis. Specifically, when the absolute asset supply $|z|$ is very small, naïve investors do not participate in the market. In such a context, as institutional sector size increases, the cost of capital decreases due to the increasing information about the asset. Conversely, when the absolute asset supply $|z|$ is sufficiently large, driving the price to the threshold levels, naïve investors entry into the market. In this scenario, as institutional sector size expands, the price contains more information, leading to a reduction in the cost of capital. However, the market share of the monopolistic investor increases proportionally in the meanwhile. Because the monopolistic investor has the incentive to attract more naïve investors in the market for risk-sharing, the cost of capital increases to attract more naïve investors to trade. Hence, we observe a non-monopolistic pattern in the impacts of institutional investors expansion on cost of capital.

3.3. Empirical implications

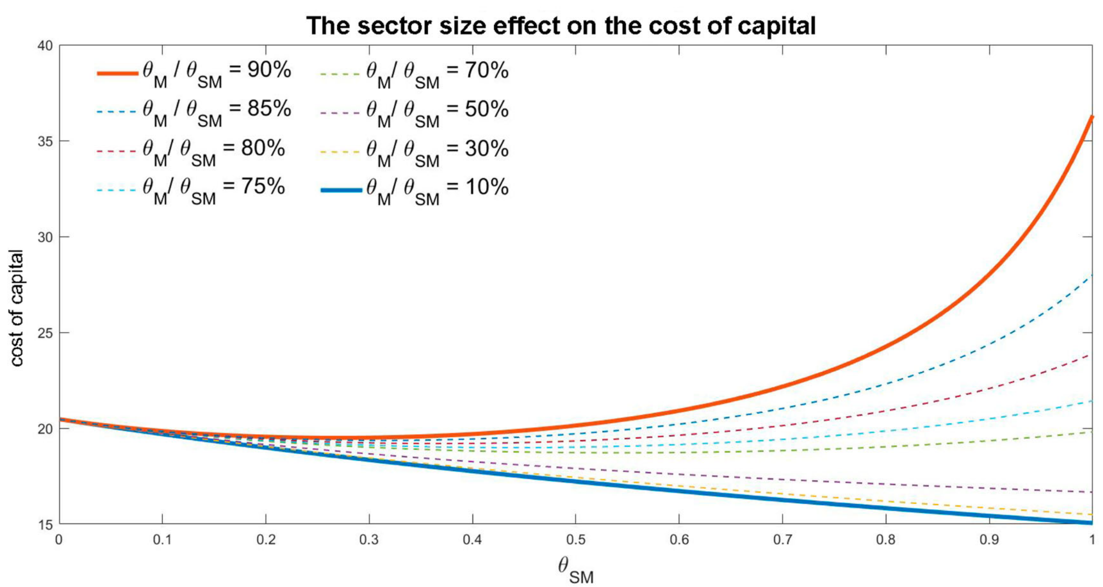
In this part, we explore the implications of our model for empirical studies in financial markets. These implications encompass various empirical measures of institutionalization, the empirical relationship between institutionalization and expected return, as well as the influence of investors' prudence attitude on asset pricing.

Our model employs two measures of institutionalization and investigates their effects on market participation and cost of capital. The first measure is θ_{SM}, defined as the total market share of all institutional investors, including both monopolistic and sophisticated investors. The second measure, ζ, quantifies the proportion of market share controlled by institutional investors with market power, particularly the monopolistic investor, in relation to the total institutional investor base. These measures reflect two critical trends in institutionalization: the relative growth of institutional investors vis–vis retail investors, and the concentration of market power among top financial institutions. The most widely used empirical measure related to θ_{SM} is the percentage of outstanding shares held by institutional investors, as reported in Securities and Exchange Commission (SEC) 13-F filings (Chen, Dong, and Lin 2020; Hartzell and Starks 2003). In addition, in our model, both monopolistic investors and sophisticated investors have information advantage compared to naïve investors, representing the market participants with prior information. Therefore, another empirical measure related to θ_{SM} is insider holdings or insider ownership derived from SEC Form 3, 4, and 5 (Agrawal and Cooper 2015; Rubin 2007). Measures closely related to ζ include ownership percentages by the top 1/5/10 largest institutional investors (Hartzell and Starks 2003; Kang, Luo, and Na 2018), ownership percentages by blockholders defined as holdings by institutions with at least 5% of the shares (Rubin 2007; Thomsen, Pedersen, and Kvist 2006), and the Herfindahl Index (Hartzell and Starks 2003).

Numerous empirical studies have investigated the relationship between institutional holdings and stock returns (Baik, Kang, and Kim 2010; Edelen, Ince, and Kadlec 2016; Nofsinger and Sias 1999; Yan and Zhang 2009). However, the conclusions drawn from these studies are not consistent. Previous research has sought to explain these divergent findings from perspectives such as corporate governance (see review by Edmans (2014) and Jensen and Meckling (2019)), trading strategies or skills of fund managers (Edelen, Ince, and Kadlec 2016; Grinblatt, Titman, and Wermers 1995; Nofsinger and Sias 1999), and private information held by institutional investors (Baik, Kang, and Kim 2010; Breugem and Buss 2019; Bushee and Goodman 2007). Our model introduces a novel insight, suggesting that market participation, especially by less-informed naïve



(a) Panel A



(b) Panel B

Figure 4. The impacts of market concentration effect and sector size effect on price premium (a,b).

investors, mediates the link between institutional holdings and stock returns. It predicts that market concentration among institutional investors promotes participation due to risk-sharing incentives from large traders, thereby increasing expected returns. Meanwhile, variations in the total market share of institutional investors can either elevate or diminish naïve investor participation, exerting a non-linear effect on expected returns. This novel viewpoint not only adds to the existing theoretical landscape but also proposes new hypotheses for empirical testing, enhancing our understanding of the dynamics between institutional holdings and stock returns.

Our analysis also highlights the critical role of investors' prudence in influencing asset pricing. Traditional finance models often assume investor rationality and the absence of systematic biases, aligning behaviors with the Expected Utility (EU) model. However, empirical evidence increasingly challenges this assumption, indicating that investor behavior deviates from traditional models (See reviews by Starmer (2000) and Machina (2008)). For instance, the phenomenon of probability weighting, where decision weights replace objective probabilities, is a notable deviation observed in financial markets (Barberis and Huang 2008; Bali, Cakici, and Whitelaw 2011; Polkovnichenko and Zhao 2013). Our model adopts the Anticipated Utility (AU) model, proposed by Quiggin (1982), allowing for such probability distortion. Specifically, we assume a concave Wang-transform probability weighting function, where the concavity reflects investors' prudence attitude.

A key finding of our model is that prudence attitude leads to limited investor participation. Note that investors' prudence attitude can be formed due to exposure to extreme negative events, such as financial depression or financial crisis.[22] Therefore, our result offers a compelling explanation for the well-documented observation that individuals impacted by financial crisis or depressions are less inclined to invest in risky assets later in life, corroborating findings from Malmendier and Nagel (2011) and Knüpfer, Rantapuska, and Sarvimäki (2017).

Furthermore, our model proposes that limited participation due to prudence attitude can lead to price jumps and flat ranges in asset prices. Given that investors with prudence attitude enter the market only at sufficiently attractive prices, there would be no trade when the price lies between. Therefore, even a minor shift in the asset supply z can result in a big price jump. While most literature associates price jumps with information shocks (Andersen, Bollerslev, and Diebold 2007; Boudt and Petitjean 2014; Lee 2012), our findings suggest that such jumps could arise from liquidity fluctuations without any new information. In fact, this has been supported by some empirical studies, such as Jiang, Lo, and Verdelhan (2011), Jiang and Yao (2013) and Scaillet, Treccani, and Trevisan (2020). For example, Jiang, Lo, and Verdelhan (2011) found that the news announcement has limited power compared with the variation in market liquidity when explaining the jumps in U.S. Treasury-bond prices. Our model also predicts specific features of price jumps, such as their occurrence during shifts in investor positions and a positive correlation with the prudence parameter α and the standard deviation of the risky asset $\hat{\sigma}$. These novel insights offer additional empirical implications to explore price jump phenomena.

Besides price jumps, our model also finds the occurrence of flat ranges in prices. Such flat, or stale, prices are a common phenomenon in financial markets (Bandi et al. 2020; Bandi, Pirino, and Reno 2017). While earlier studies, such as Harris (1991), have attributed flat prices to factors such as price rounding, Bandi et al. (2020) argue that rounding accounts for only a minor portion of these occurrences. Our model offers an alternative explanation, suggesting that the flat prices arise from limited participation by naïve investors and the price impact of monopolistic investors. In particular, the monopolistic trader has to increase expected returns to encourage participation from naïve investors for the risk-sharing purpose. However, this increase in expected returns would simultaneously reduce the monopolistic investor's trading profits. Therefore, if the risk-sharing benefits fail to outweigh the costs, the monopolistic investor may opt to bear the risks on her own, leading to unaltered prices. Bandi et al. (2020) also observe a positive relationship between stale price and low trading volume. Our model aligns with this finding, predicting that flat prices occur when the absolute value of asset supply z is relatively low.

In conclusion, our findings offer a novel perspective on the relationship between institutionalization and expected returns. They resonate with previous empirical research highlighting limited market participation, price jumps, and flat-price ranges, while also providing a suite of testable implications for future empirical investigations.

4. Conclusion

Decades of discourse on the influence of institutional investors on market efficiency have failed to yield a consensus. The recent surge in institutional trading activity has reignited this debate. In this paper, we explore the impacts of two prominent trends in the process of institutionalization: the expansion of institutional sector size and the concentration of market shares in top institutions. To capture these two trends, we develop an imperfect competitive market model featuring three types of traders, representing top financial institutions, smaller institutions, and retail investors. These traders have varying market power and distinct information about the asset payoff. Different from the previous literature, we incorporate a prudence attitude into our model to depict investors' distorted decision-making. We find that investors' prudence attitude significantly affects their participation decisions and thereafter leads to a price jump in equilibrium. A more prudent investor is inclined to overweight extreme adverse events while underweighting positive outcomes, indicating that she requires a higher compensation for her probability aversion. Therefore, if the asset fails to yield a sufficiently high premium, prudent investors will refrain from the market, resulting in an absence of trades and the inability to form an equilibrium price.

Our model also reveals that, although the intensifying market concentration and the expanding sector size are two aspects of institutionalization, they have different impacts on the cost of capital and market participation. Market concentration constantly raises the cost of capital and encourages naïve traders to participate in the market, whereas the magnifying sector size has inconsistent impacts. In most cases, an expanding sector size tends to lower the cost of capital and hinder naïve traders' participation. However, if the asset has relatively large supply and the market is highly concentrated, U-shaped effects on price premium and on market participation will emerge. We attribute these divergent impacts to the interplay between the information channel and the risk-sharing channel. When the market is more concentrated in top institutions, these market-powered traders are prone to induce more participation from naïve investors to share market risks with them, therefore the cost of capital rises accordingly to meet the return requirement by naïve traders. Conversely, when the sector size expands, there are more informed institutional traders in the market, which drives the asset price to its fundamental value and hence decreases the cost of capital. Eventually, these two opposing effects shape the overall impacts of institutionalization.

While this study centers on the influence of institutionalization in markets characterized by prudent traders, the underlying principles and methodology have the potential for application in a wider range of scenarios. For instance, future models could accommodate varying probability attitudes and consider wealth effects among different investors. Additionally, the current model, structured within a simplistic one-period framework, offers a foundation for expansion into multi-period settings. Such an extension would allow for more nuanced exploration into information acquisition and dynamic trading analysis. Finally, as discussed in the previous section, our model presents a variety of empirical implications for exploration in future research.

Notes

1. The distribution of institutional ownership is severely skewed (Kacperczyk, Nosal, and Sundaresan 2023). For example, in 2017, institutional investors possessed around 80% of shares of the S&P 500 companies, with the 'Giant Three' managing more than 25% of these institutional holdings (Bebchuk and Hirst 2019).
2. Extensive evidence has documented that investors' trading behavior deviates from what expected utility models forecast. Many non-EU theories are therefore proposed to model investors' decision-making process, i.e. (Gilboa and Schmeidler 1989; Kahneman and Tversky 1973; Quiggin 1982; Schmeidler 1986, 1989; Tversky and Kahneman 1992), etc. (Wakker 2010) addresses the importance of non-EU theories and pays special attention to the role of AU/prospect theory in analyzing investors' behavior.
3. Huang, Wang, and Zhang (2021) examine the trading behavior of investors with concave probability weighting function. In their paper, investors' sensitivity towards probability is depicted by the concavity of probability weighting function; their tendency to overweight extremely negative outcomes and to underweight extremely positive outcomes is called prudence attitude. We follow their paper by referring investors with concave Wang-transformed probabilities to as having prudence attitude.
4. For simplification, we assume that the risk-free asset has a constant price, i.e. the risk-free rate is zero. Our main results remain unchanged when the risk-free rate is positive.
5. Our main results remain unchanged if the utility function is $u(w) = \frac{1}{\gamma}(1 - e^{-\gamma w})$.
6. In our model, naïve traders can be regarded as retail traders, who have insufficient knowledge or information about financial markets; therefore, we suppose that they neither have a correct belief about the asset payoff due to their information shortage, nor the ability to learn from the market.
7. In our model, we assume that all traders have the same initial wealth W_0. This assumption can be lifted, because we suppose all traders have CARA utility, where the wealth effect is absent. As a consequence, investors' initial wealth has little impact on their portfolio choices. But even if we use other models to evaluate traders' utility level, an assumption that traders have differential initial wealth does not alter our main findings, because we can capture investors' impacts by adjusting their relative proportions.
8. An agent's attitude towards uncertainty can be divided into her attitudes toward outcomes and toward probabilities. Here in our model, we use CARA utility function to describe traders' aversion attitudes toward outcomes. At the same time, their preferences toward probabilities are depicted by the Wang transform distortion function with $\alpha > 0$, which reflects their prudence attitude.

9. The proof is in the Appendix.
10. The maximization of AU is equivalent to the maximization of CE. This is because in our model, we assume all investors have CARA utility function, $u(w) = -\mathrm{e}^{-\gamma w}$, which is an increasing function in w. Therefore, maximizing the utility $u(w)$ is equivalent to maximize w. In this sense, the maximization of $AU(\tilde{W}) = -\mathrm{e}^{-\gamma[\mu_{\tilde{W}} - \alpha\sigma_{\tilde{W}} - \frac{1}{2}\gamma\sigma^2_{\tilde{W}}]}$ is the same as maximizing $\mu_{\tilde{W}} - \alpha\sigma_{\tilde{W}} - \frac{1}{2}\gamma\sigma^2_{\tilde{W}}$, which is the certainty equivalent of the anticipated utility.
11. Similar to Easley and O'Hara (2009) and Easley and O'Hara (2010), we assume that traders form their beliefs about the mean and the standard deviation separately, which means that $\hat{\mu}$ and $\hat{\sigma}$ are two independent variables.
12. Σ^2 can be viewed as the variance perceived by naïve traders, which in some ways reflects their confidence about the market. In our model, we assume that $\Sigma^2 > \hat{\sigma}^2$; that is, naïve traders think the variance of the risky asset is greater than it should be, and this lack of confidence comes from their information shortage.
13. The market supply z needs not necessarily be positive, it can be zero or take a negative number. Similarly, in the left-hand side of the market clearing condition, traders' demand for the risky asset can be negative, signifying their intend to hold short positions in the risky asset. A negative supply z can be interpreted as a liquidity shock, indicating an insufficient net supply of the risky asset in the market. In such cases, if a trader wants to buy the risky asset, she has to purchase from other investors.
14. The price $p(x)$ in the optimization problem (6) is a function of monopolistic traders' optimal demand, which is derived from the market-clearing condition.
15. This 'no-participation' phenomenon also refers to as 'portfolio inertia' that the demand for the risky asset does not change with its Sharpe ratio.
16. The setting that $\Sigma^2 > \hat{\sigma}^2$ does not restrict the location of $\hat{\sigma}$ in the interval $[\underline{\sigma}, \overline{\sigma}]$. We can rewrite $\hat{\sigma}$ as $\hat{\sigma} = \underline{\sigma} + m \cdot (\overline{\sigma} - \underline{\sigma})$, where $m \in [0, 1]$ shows the relative location of $\hat{\sigma}$ in the interval. Then, the assumption $\Sigma^2 > \hat{\sigma}^2$ is equivalent to $0 \leqslant m < \frac{\sqrt{3(\overline{\sigma}^2 + \overline{\sigma}\underline{\sigma} + \underline{\sigma}^2)} - 3\underline{\sigma}}{3(\overline{\sigma} - \underline{\sigma})}$, where the upper-bound of m is between 0.5 and $\sqrt{3}/3$ depending on the value of $\frac{\overline{\sigma}}{\underline{\sigma}}$. Therefore, $\hat{\sigma}$ could either be in the upper half or bottom half of the interval $[\underline{\sigma}, \overline{\sigma}]$.
17. In our model, the ratio of the correct variance to the perceived variance $\hat{\sigma}^2/\Sigma^2$ can be regarded as a measure of information asymmetry between traders. This is because naïve traders do not have sufficient information to properly estimate the true variance of asset payoff, so they form a belief that the variance is Σ^2, which, according to our previous assumption, is greater than $\hat{\sigma}^2$. This inequality implies that, if the perceived variance Σ^2 is closer to the true variance $\hat{\sigma}^2$, that is, if the portfolio choice of naïve traders under insufficient information aligns more closely with a rational choice under sufficient information, then these naïve traders will be less adversely affected by asymmetric information. Therefore, when the ratio converges to 1, signifying that the perceived variance Σ^2 is closer to the correct variance $\hat{\sigma}^2$, the information asymmetry is less severe; vice versa.
18. Due to limited space, we only exhibit equilibrium asset price in each scenario. The equilibrium positions of different traders can be easily obtained by inserting equilibrium price into their demand functions (Equations (7), (8), and (12)).
19. This same-trading-direction phenomenon is consistent with the common finding of institutional herding. Institutional herding can be intentional or unintentional (Kremer and Nautz 2013; Sias 2004), and in our paper, the herding arises unintentionally.
20. The discussion with negative asset supply is an asymmetry to the positive case.
21. In our paper, if we set the parameter α in the Wang transform to be zero, the model is then degenerated to an EU case.
22. Literature finds that people would overweight recently sampled information, such as their own encounters when they are making decisions (Hertwig et al. 2004). Therefore, investors who have experienced financial depression are more likely to overweight the probability of extreme negative outcomes and underweight the probability of extreme positive outcomes, displaying prudence attitude.

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Appendix

A.1 Proof of traders' anticipated utility w.r.t. the Wang transform

Proof: In this paper, we suppose that traders' well-being is evaluated by the anticipated utility, as shown in Equation (1), and we adopt the Wang transform to serve as their distortion operator. Moreover, according to the normal property of asset payoff, we know that the final wealth of the traders follows a normal distribution as well, $\tilde{W} \sim N(\mu_{\tilde{W}}, \sigma^2_{\tilde{W}})$. Therefore, the anticipated utility of traders w.r.t. the Wang transform is calculated as

$$\begin{aligned} AU(\tilde{W}) &= \int_{\mathbb{R}} u(w)\, \mathrm{d}g_\alpha \left(F_{\tilde{W}}(w)\right) \\ &= \int_{\mathbb{R}} u(w)\, \mathrm{d}\Phi \left(\Phi^{-1}\left(F_{\tilde{W}}(w)\right) + \alpha\right) \\ &= \int_{\mathbb{R}} u(w)\, \mathrm{d}\Phi \left(\frac{w - \mu_{\tilde{W}}}{\sigma_{\tilde{W}}} + \alpha\right) \\ &= \int_{\mathbb{R}} u\left(\mu_{\tilde{W}} - \alpha\sigma_{\tilde{W}} + \sigma_{\tilde{W}} w\right) d\Phi(w) \\ &= -\mathrm{e}^{-\gamma\left[\mu_{\tilde{W}} - \alpha\sigma_{\tilde{W}} - \frac{1}{2}\gamma\sigma^2_{\tilde{W}}\right]}. \end{aligned}$$

■

A.2 Proof of Theorem 2.1

Proof: We first solve the demand functions of sophisticated and naïve traders.

For sophisticated traders, their optimization problem is shown in Equation (3) We solve it regarding the signs of x_S.

When $x_S > 0$, by solving the first-order condition of Equation (3), we can obtain sophisticated traders' demand function as:

$$x_S = \frac{\hat{\mu} - p - \alpha\hat{\sigma}}{\gamma\hat{\sigma}^2},$$

where $p < \hat{\mu} - \alpha\hat{\sigma}$ to guarantee that $x_S > 0$.

When $x_S < 0$, by solving the first-order condition, we have:

$$x_S = \frac{\hat{\mu} - p + \alpha\hat{\sigma}}{\gamma\hat{\sigma}^2},$$

where $p > \hat{\mu} + \alpha\hat{\sigma}$. We summarize the demand function of sophisticated traders in Equation (7). The demand function of the naïve traders is solved in the same way and shown in Equation (8).

Next, given the demand functions of sophisticated investors and the naïve investors $x_S(p)$ and $x_N(p)$ and the market clearing condition, we solve the price as a function of the demand of monopolistic traders $p(x_M)$.

Substituting Equations (7) and (8) into the market clearing condition Equation (5), we obtain the market price as a function of x_M in Equation (9) and the price impact of the monopolistic traders in Equation (10). Denote $\overline{z} \equiv \frac{(\hat{\mu}-\alpha\hat{\sigma})-(E[\mu]-\alpha E[\sigma])}{\gamma\hat{\sigma}^2} > 0$, and $\underline{z} \equiv \frac{(\hat{\mu}+\alpha\hat{\sigma})-(E[\mu]+\alpha E[\sigma])}{\gamma\hat{\sigma}^2} < 0$. This calculation process is as follows:

- If $p < E[\mu] - \alpha E[\sigma]$, the corresponding market clearing condition is

$$\theta_S \frac{\hat{\mu} - p - \alpha\hat{\sigma}}{\gamma\hat{\sigma}^2} + \theta_N \frac{E[\mu] - p - \alpha E[\sigma]}{\gamma\Sigma^2} + \theta_M x_M = z.$$

The price is solved as a function of x_M, i.e.

$$p = \hat{\mu} - \alpha\hat{\sigma} - \gamma\left[\frac{\theta_S}{\hat{\sigma}^2} + \frac{\theta_N}{\Sigma^2}\right]^{-1}\left[\theta_N \frac{\hat{\sigma}^2}{\Sigma^2}\overline{z} + z - \theta_M x_M\right],$$

where $x_M < \frac{z - \theta_S\overline{z}}{\theta_M}$ to guarantee that $p < E[\mu] - \alpha E[\sigma]$.

- If $E[\mu] - \alpha E[\sigma] \leqslant p < \hat{\mu} - \alpha\hat{\sigma}$, the corresponding market clearing condition is

$$\theta_S \frac{\hat{\mu} - p - \alpha\hat{\sigma}}{\gamma\hat{\sigma}^2} + \theta_M x_M = z,$$

and therefore, the price function w.r.t x_M in this scenario is

$$p = \hat{\mu} - \alpha\hat{\sigma} + \frac{\gamma\hat{\sigma}^2}{\theta_S}\left(\theta_M x_M - z\right),$$

where x_M satisfies $\frac{z - \theta_S \bar{z}}{\theta_M} \leqslant x_M < \frac{z}{\theta_M}$.
- If $\hat{\mu} - \alpha\hat{\sigma} \leqslant p \leqslant \hat{\mu} + \alpha\hat{\sigma}$, in this scenario, $x_S = x_N = 0$ and therefore $x_M = \frac{z}{\theta_M}$; the price cannot be determined.
- If $\hat{\mu} + \alpha\hat{\sigma} < p \leqslant E[\mu] + \alpha E[\sigma]$, the corresponding market clearing condition is

$$\theta_S \frac{\hat{\mu} - p + \alpha\hat{\sigma}}{\gamma\hat{\sigma}^2} + \theta_M x_M = z,$$

and therefore the price function w.r.t x_M in this scenario is

$$p = \hat{\mu} + \alpha\hat{\sigma} + \frac{\gamma\hat{\sigma}^2}{\theta_S}\left(\theta_M x_M - z\right),$$

where x_M satisfies $\frac{z}{\theta_M} < x_M \leqslant \frac{z - \theta_S \underline{z}}{\theta_M}$.
- If $E[\mu] + \alpha E[\sigma] < p$, the corresponding market clearing condition is

$$\theta_S \frac{\hat{\mu} - p + \alpha\hat{\sigma}}{\gamma\hat{\sigma}^2} + \theta_N \frac{E[\mu] - p + \alpha E[\sigma]}{\gamma\Sigma^2} + \theta_M x_M = z,$$

and therefore the price function w.r.t x_M in this scenario is

$$p = \hat{\mu} + \alpha\hat{\sigma} - \left[\frac{\theta_S}{\gamma\hat{\sigma}^2} + \frac{\theta_N}{\gamma\Sigma^2}\right]^{-1}\left[\theta_N \frac{\hat{\sigma}^2}{\Sigma^2}\underline{z} + z - \theta_M x_M\right],$$

where x_M satisfies $x_M > \frac{z - \theta_S \underline{z}}{\theta_M}$.

Hence, we obtain the expression of asset price as a function of x_M and can therefore get the price impact of monopolistic traders, $p'(x_M)$, as shown in Equations (9) and (10), respectively. Figures A1 and A2 plot the price function and the price impact w.r.t. x_M.

Then, we solve the optimal demand of monopolistic traders given the price function $p(x_M)$.

The F.O.C of monopolistic traders' optimization problem is shown in Equation (11). By replacing $p(x_M)$ and $p'(x_M)$ in Equations (11) with (9) and (10), respectively, together with a separated consideration regarding the signs of x_M, we get the equilibrium position of monopolistic traders in Equation (12). Below, we show the calculation process of the scenarios where $x_M > 0$. Note that the cases of $x_M < 0$ are exactly symmetrical.

If $x_M > 0$, F.O.C of Equation (11) solves the demand function of the monopolistic traders, that is

$$x_M = \frac{\hat{\mu} - p(x_M) - \alpha\hat{\sigma}}{p'(x_M) + \gamma\hat{\sigma}^2}.$$

- When $p < E[\mu] - \alpha E[\sigma]$, taking Equations (9) and (10) into the demand function, we obtain the equilibrium position of the monopolistic $x_M = \frac{\theta_N \frac{\hat{\sigma}^2}{\Sigma^2}\bar{z} + z}{\theta_S + 2\theta_M + \theta_N \frac{\hat{\sigma}^2}{\Sigma^2}}$. Moreover, the condition $0 < x_M < \frac{z - \theta_S \bar{z}}{\theta_M}$ is equivalent to $\frac{\theta_S\theta_M + (\theta_S + \theta_M)\left(\theta_S + \theta_N \frac{\hat{\sigma}^2}{\Sigma^2}\right)}{\theta_S + \theta_M + \theta_N \frac{\hat{\sigma}^2}{\Sigma^2}}\bar{z} < z$.
- When $E[\mu] - \alpha E[\sigma] \leqslant p < \hat{\mu} - \alpha\hat{\sigma}$, the equilibrium position is $x_M = \frac{z}{\theta_S + 2\theta_M}$, and the conditions $\frac{z - \theta_S \bar{z}}{\theta_M} \leqslant x_M < \frac{z}{\theta_M}$ and $x_M > 0$ are equivalent to $0 < z \leqslant \frac{\theta_S\theta_M + (\theta_S + \theta_M)\theta_S}{\theta_S + \theta_M}\bar{z}$. It is worth noticing that there is a gap between the above two scenarios,

$$\frac{\theta_S\theta_M + (\theta_S + \theta_M)\theta_S}{\theta_S + \theta_M}\bar{z} < z \leqslant \frac{\theta_S\theta_M + (\theta_S + \theta_M)\left(\theta_S + \theta_N \frac{\hat{\sigma}^2}{\Sigma^2}\right)}{\theta_S + \theta_M + \theta_N \frac{\hat{\sigma}^2}{\Sigma^2}}\bar{z},$$

in which a corner solution lies, with $x_M = \frac{z - \theta_S \bar{z}}{\theta_M}$.
- When $\hat{\mu} - \alpha\hat{\sigma} \leqslant p \leqslant \hat{\mu} + \alpha\hat{\sigma}$, the equilibrium position is $x_M = \frac{z}{\theta_M}$. In this case, the price impact of the monopolistic traders converges to infinite $p'(x_M) \to \infty$, which makes $x_M = \frac{\hat{\mu} - p(x_M) - \alpha\hat{\sigma}}{p'(x_M) + \gamma\hat{\sigma}^2} \to 0$. So the scenario exists only if $z \downarrow 0$.
- When $p > \hat{\mu} + \alpha\hat{\sigma}$, $x_M < 0$, which contradicts to the prerequisite that $x_M > 0$.

If $x_M = 0$, we have $p(x_M) \in \left[\hat{\mu} - \alpha\hat{\sigma}, \hat{\mu} + \alpha\hat{\sigma}\right]$, in which the market clearing condition is satisfied only if $z = 0$. Finally, the proof of the case where $x_M < 0$ is symmetrical to the case of $x_M > 0$.

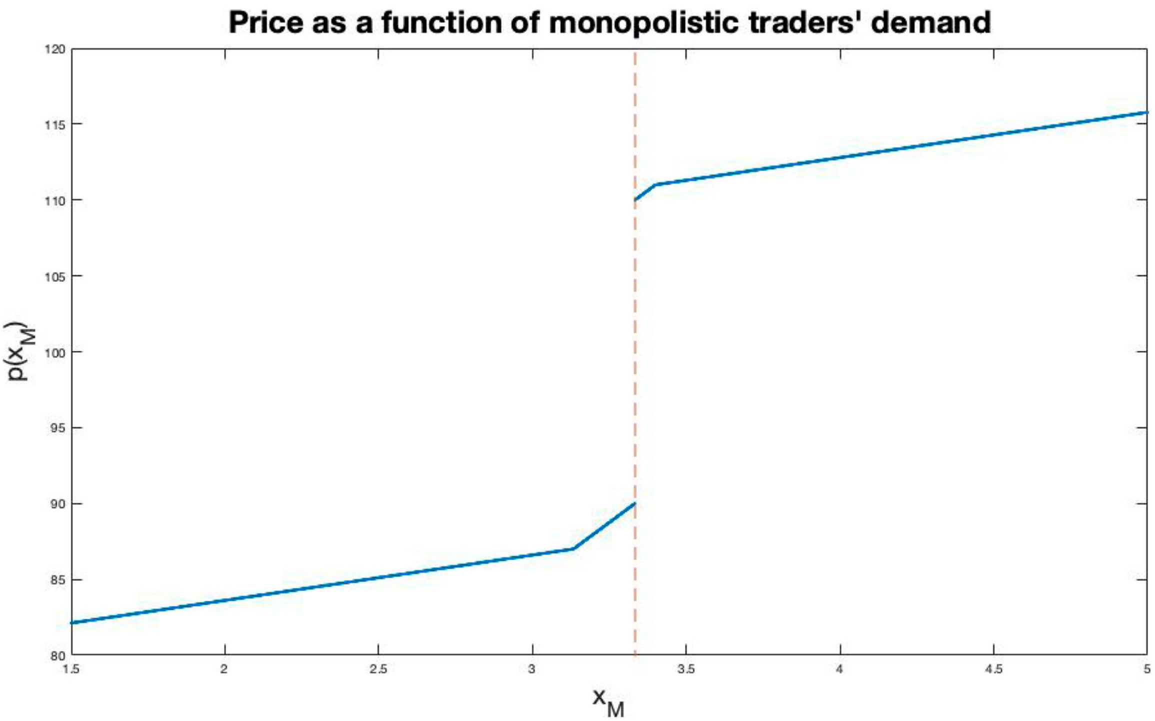

Figure A1. Asset price w.r.t. monopolistic traders' demand.

This figure plots the asset price as a function of monopolistic traders' demand p(x M). We set $\gamma = 0.05$, $\alpha = 1$, θ SM = 40%, θ M/θ SM = 0.75, θ N = 1− θ SM, μ = 100, $\sigma = 10$, μ = 103, μ = 95, $\sigma = 16$, $\sigma = 8$, z = 1, x M ∈ [1.5, 5].

Finally, by taking the equilibrium position of monopolistic traders x_M into the price function $p(x_M)$, we obtain the market equilibrium, as shown in Theorem 2.1. ■

A.3 Proof of Proposition 3.1

Proof: First, we prove that the market concentration will increase market participation by naïve investors.

In our paper, the market concentration effect (without increasing the total proportion of institutions) can be represented by an increasing ζ *while keeping* θ_{SM} *fixed*. Let us first look into the effect of market concentration on the willingness of naïve traders to participate in the market.

Given the definition of non-participation range in Equation (19) and market concentration level ζ in Equation (21), we can rewrite the non-participation range as:

$$\text{Non}-\text{participation range} = \frac{2\alpha}{\gamma}\left[\frac{2(1-\zeta)\theta_{SM}^2 - (1-\zeta)^2\theta_{SM}^2 + \theta_{SM}(1-\theta_{SM})\frac{\hat{\sigma}^2}{\Sigma^2}}{\theta_{SM} + (1-\theta_{SM})\frac{\hat{\sigma}^2}{\Sigma^2}}\right]\left(\frac{E[\sigma]-\hat{\sigma}}{\hat{\sigma}^2}\right). \tag{A1}$$

Taking derivative over the non-participation range in Equation (A1) on ζ, we have:

$$\frac{\partial \text{Non}-\text{participation range}}{\partial \zeta} = -\frac{4\alpha}{\gamma}\left[\frac{\zeta\theta_{SM}^2}{\theta_{SM} + (1-\theta_{SM})\frac{\hat{\sigma}^2}{\Sigma^2}}\right]\left(\frac{E[\sigma]-\hat{\sigma}}{\hat{\sigma}^2}\right) < 0.$$

Therefore, as the market concentration level is increasing, the non-participation range of naïve investors is decreasing.

Next, we investigate how sector size affects the market participation by naïve investors.

In our paper, the size effect is shown by an increasing θ_{SM} with the relative ratio ζ fixed. By taking derivative over the non-participation range in Equation (A1) on θ_{SM}, we have:

$$\frac{\partial \text{Non}-\text{participation range}}{\partial \theta_{SM}} = \frac{2\alpha}{\gamma}\left(\frac{E[\sigma]-\hat{\sigma}}{\hat{\sigma}^2}\right)\left[\theta_{SM} + (1-\theta_{SM})\frac{\hat{\sigma}^2}{\Sigma^2}\right]^{-2} Q,$$

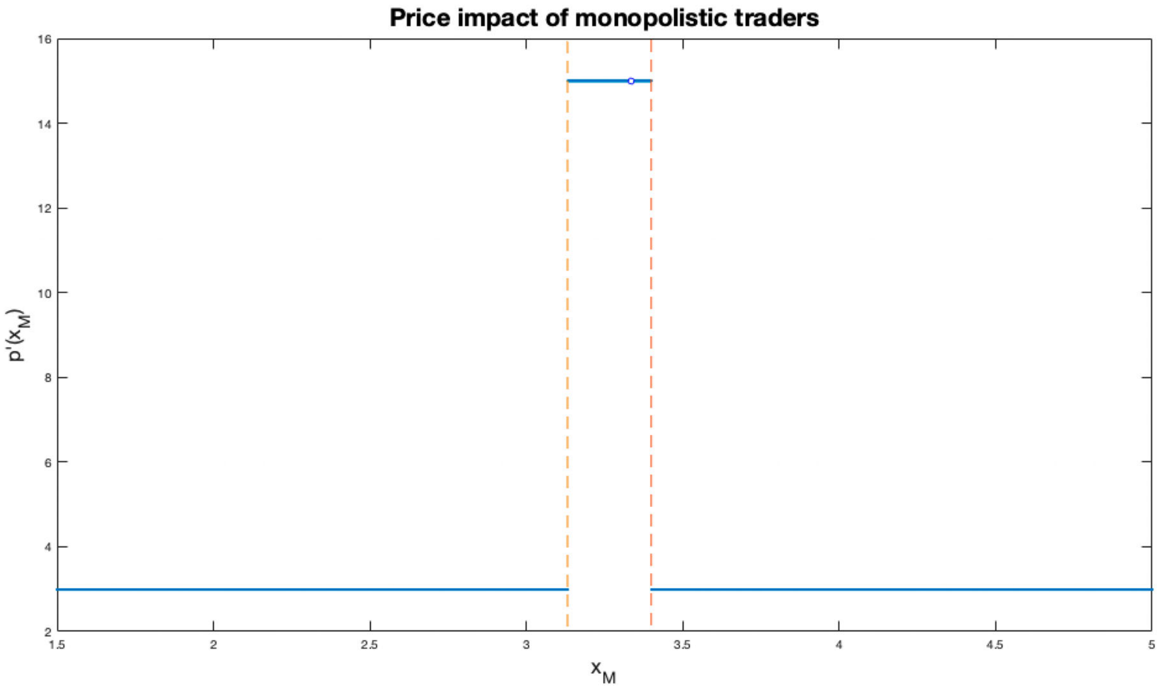

Figure A2. Price impact of monopolistic traders.

This figure plots the price impact of monopolistic traders p′(x M). We set $\gamma = 0.05$, $\alpha = 1$, θ SM $=$ 40%, θ M / θ SM $=$ 0.75, θ N $=$ 1 - θ SM, μ $=$ 100, $\sigma = 10$, μ $=$ 103, μ $=$ 95, $\sigma = 16$, $\sigma = 8$, z $=$ 1, x M ∈ [1.5, 5].

where

$$Q \equiv \left(1 - \frac{\hat{\sigma}^2}{\Sigma^2}\right)\left(1 - \zeta^2 - \frac{\hat{\sigma}^2}{\Sigma^2}\right)\theta_{SM}^2 + 2\frac{\hat{\sigma}^2}{\Sigma^2}\left(1 - \zeta^2 - \frac{\hat{\sigma}^2}{\Sigma^2}\right)\theta_{SM} + \left(\frac{\hat{\sigma}^2}{\Sigma^2}\right)^2.$$

Therefore, discussing the monotonicity of z_1 w.r.t θ_{SM} is equivalent to discussing the signs of Q, which is a quadratic function of θ_{SM}.

The discriminant of Q is:

$$\Delta = -4\zeta^2\left(\frac{\hat{\sigma}^2}{\Sigma^2}\right)^2\left(1 - \zeta^2 - \frac{\hat{\sigma}^2}{\Sigma^2}\right).$$

Therefore, when $1 - \zeta^2 - \frac{\hat{\sigma}^2}{\Sigma^2} \geqslant 0$, i.e, $0 \leqslant \zeta < \sqrt{1 - \frac{\hat{\sigma}^2}{\Sigma^2}}$, we have $\Delta < 0$ so that $Q > 0$ always holds. Then, the non-participation range is increasing with θ_{SM} if $0 \leqslant \zeta < \sqrt{1 - \frac{\hat{\sigma}^2}{\Sigma^2}}$.

When $1 - \zeta^2 - \frac{\hat{\sigma}^2}{\Sigma^2} < 0$, i.e. $\sqrt{1 - \frac{\hat{\sigma}^2}{\Sigma^2}} < \zeta \leqslant 1$, we have $\Delta > 0$. We find that when $\theta_{SM} < -\frac{\hat{\sigma}^2}{\Sigma^2}\frac{\left(1-\zeta^2-\frac{\hat{\sigma}^2}{\Sigma^2}\right)+\zeta\left[-\left(1-\zeta^2-\frac{\hat{\sigma}^2}{\Sigma^2}\right)\right]^{\frac{1}{2}}}{\left(1-\frac{\hat{\sigma}^2}{\Sigma^2}\right)\left(1-\zeta^2-\frac{\hat{\sigma}^2}{\Sigma^2}\right)}$, we have $Q > 0$; whereas when $\theta_{SM} > -\frac{\hat{\sigma}^2}{\Sigma^2}\frac{\left(1-\zeta^2-\frac{\hat{\sigma}^2}{\Sigma^2}\right)+\zeta\left[-\left(1-\zeta^2-\frac{\hat{\sigma}^2}{\Sigma^2}\right)\right]^{\frac{1}{2}}}{\left(1-\frac{\hat{\sigma}^2}{\Sigma^2}\right)\left(1-\zeta^2-\frac{\hat{\sigma}^2}{\Sigma^2}\right)}$,we have $Q < 0$. Therefore, the non-participation range displays an inverse U-shaped relationship with θ_{SM} if $\sqrt{1 - \frac{\hat{\sigma}^2}{\Sigma^2}} < \zeta \leqslant 1$.

Proposition 3.1 summarizes the results. ■

A.4 Proof of Proposition 3.2

Proof: We first consider the market concentration effect on the cost of capital.

For simplification, we use ‘CC’ to denote the ‘Cost of Capital’ in this proof. The effect of market concentration can be shown by the signs of the derivative, which is:

$$\frac{\partial CC}{\partial \zeta} = \text{sign}(p - \hat{\mu}) \cdot \frac{\partial p}{\partial \zeta}. \tag{A2}$$

Since equilibrium price has different forms depending on the ranges of asset supply z, we discuss the derivative of the cost of capital w.r.t ζ in each scenario as follows:

- When $z < \frac{\theta_S\theta_M + (\theta_S+\theta_M)\left(\theta_S+\theta_N\frac{\hat{\sigma}^2}{\Sigma^2}\right)}{\theta_S+\theta_M+\theta_N\frac{\hat{\sigma}^2}{\Sigma^2}}\underline{z}$, from Theorem 2.1 and the definition of θ_{SM} and ζ, the equilibrium price is rewritten as:

$$p = \hat{\mu} + \alpha\hat{\sigma} - \frac{\gamma\hat{\sigma}^2\left[(1-\theta_{SM})\frac{\hat{\sigma}^2}{\Sigma^2}\underline{z} + z\right]\left[\theta_{SM} + (1-\theta_{SM})\frac{\hat{\sigma}^2}{\Sigma^2}\right]}{\left[\theta_{SM} + (1-\theta_{SM})\frac{\hat{\sigma}^2}{\Sigma^2}\right]^2 - \zeta^2\theta_{SM}^2}. \tag{A3}$$

  Therefore, we have $\frac{\partial \mathrm{CC}}{\partial \zeta} > 0$.
- When $\frac{\theta_S\theta_M + (\theta_S+\theta_M)\left(\theta_S+\theta_N\frac{\hat{\sigma}^2}{\Sigma^2}\right)}{\theta_S+\theta_M+\theta_N\frac{\hat{\sigma}^2}{\Sigma^2}}\underline{z} \leqslant z < \frac{\theta_S\theta_M+(\theta_S+\theta_M)\theta_S}{\theta_S+\theta_M}\underline{z}$, the equilibrium price is a constant. Therefore, in this scenario, $\frac{\partial \mathrm{CC}}{\partial \zeta} = 0$.
- When $\frac{\theta_S\theta_M+(\theta_S+\theta_M)\theta_S}{\theta_S+\theta_M}\underline{z} \leqslant z < 0$, from Theorem 2.1 and the definition of θ_{SM} and ζ, the equilibrium price is rewritten as:

$$p = \hat{\mu} + \alpha\hat{\sigma} - \frac{\gamma\hat{\sigma}^2 z}{(1-\zeta^2)\theta_{SM}}. \tag{A4}$$

  Therefore, $\frac{\partial \mathrm{CC}}{\partial \zeta} > 0$.
- When $0 < z \leqslant \frac{\theta_S\theta_M+(\theta_S+\theta_M)\theta_S}{\theta_S+\theta_M}\overline{z}$, from Theorem 2.1 and the definition of θ_{SM} and ζ, the equilibrium price is rewritten as:

$$p = \hat{\mu} - \alpha\hat{\sigma} - \frac{\gamma\hat{\sigma}^2 z}{(1-\zeta^2)\theta_{SM}}. \tag{A5}$$

  Therefore, $\frac{\partial \mathrm{CC}}{\partial \zeta} = -\frac{\partial p}{\partial \zeta} > 0$.
- When $\frac{\theta_S\theta_M+(\theta_S+\theta_M)\theta_S}{\theta_S+\theta_M}\overline{z} < z \leqslant \frac{\theta_S\theta_M + (\theta_S+\theta_M)\left(\theta_S+\theta_N\frac{\hat{\sigma}^2}{\Sigma^2}\right)}{\theta_S+\theta_M+\theta_N\frac{\hat{\sigma}^2}{\Sigma^2}}\overline{z}$, the equilibrium price is a constant. Therefore, $\frac{\partial \mathrm{CC}}{\partial \zeta} = -\frac{\partial p}{\partial \zeta} = 0$.
- When $\frac{\theta_S\theta_M + (\theta_S+\theta_M)\left(\theta_S+\theta_N\frac{\hat{\sigma}^2}{\Sigma^2}\right)}{\theta_S+\theta_M+\theta_N\frac{\hat{\sigma}^2}{\Sigma^2}}\overline{z} < z$, from Theorem 2.1 and the definition of θ_{SM} and ζ, the equilibrium price is rewritten as:

$$p = \hat{\mu} - \alpha\hat{\sigma} - \frac{\gamma\hat{\sigma}^2\left[(1-\theta_{SM})\frac{\hat{\sigma}^2}{\Sigma^2}\overline{z} + z\right]\left[\theta_{SM} + (1-\theta_{SM})\frac{\hat{\sigma}^2}{\Sigma^2}\right]}{\left[\theta_{SM} + (1-\theta_{SM})\frac{\hat{\sigma}^2}{\Sigma^2}\right]^2 - \zeta^2\theta_{SM}^2}, \tag{A6}$$

  Therefore, $\frac{\partial \mathrm{CC}}{\partial \zeta} = -\frac{\partial p}{\partial \zeta} > 0$.

In sum, the cost of capital is always (not strictly) increasing in ζ.

Next, we investigate the sector size effect on cost of capital. Similar to the prior analysis, we discuss the sector size effect in different scenarios depending on the ranges of asset supply z.

The marginal sector size effect is calculated by $\frac{\partial \mathrm{CC}}{\partial \theta_{SM}} = \mathrm{sign}(p-\hat{\mu}) \cdot \frac{\partial p}{\partial \theta_{SM}}$. The derivative of equilibrium price w.r.t θ_{SM} in each scenario is listed as follows:

- When $z < \frac{\theta_S\theta_M + (\theta_S+\theta_M)\left(\theta_S+\theta_N\frac{\hat{\sigma}^2}{\Sigma^2}\right)}{\theta_S+\theta_M+\theta_N\frac{\hat{\sigma}^2}{\Sigma^2}}\underline{z}$, the equilibrium price has the form in Equation (A3). Note that the sign of $\frac{\partial p}{\partial \theta_{SM}}$ equals to:

$$\mathrm{sign}\left[\frac{\partial p}{\partial \theta_{SM}}\right] = -\mathrm{sign}\left(a\,\theta_{SM}^2 + b\,\theta_{SM} + c\right)$$

  where:

$$\begin{aligned}
a &\equiv -\left(\left[\hat{\sigma}^2\underline{z} + (\Sigma^2-\hat{\sigma}^2)z\right](\Sigma^2-\hat{\sigma}^2)^2 + \Sigma^2\zeta^2\left[\hat{\sigma}^4\underline{z} - \hat{\sigma}^2\underline{z}(\Sigma^2-\hat{\sigma}^2) - z\Sigma^2(\Sigma^2-\hat{\sigma}^2)\right]\right),\\
b &\equiv 2\hat{\sigma}^2\left[\left(\hat{\sigma}^2\underline{z} + \Sigma^2 z\right)\zeta^2\Sigma^2 - \left(\hat{\sigma}^2\underline{z} + (\Sigma^2-\hat{\sigma}^2)z\right)(\Sigma^2-\hat{\sigma}^2)\right],\\
c &\equiv -\left[\hat{\sigma}^2\underline{z} + (\Sigma^2-\hat{\sigma}^2)z\right]\hat{\sigma}^4.
\end{aligned}$$

  The discriminant of the quadratic equation $a\,\theta_{SM}^2 + b\,\theta_{SM} + c = 0$ is:

$$\Delta = 4\Sigma^4\sigma^4\zeta^2\left[\left(\hat{\sigma}^2\underline{z} + \Sigma^2 z\right)^2\zeta^2 - \left(\hat{\sigma}^2\underline{z} + \left(\Sigma^2-\hat{\sigma}^2\right)z\right)(\hat{\sigma}^2\underline{z} + \Sigma^2 z) + \left(\hat{\sigma}^2\underline{z} + (\Sigma^2-\hat{\sigma}^2)z\right)\hat{\sigma}^2 z\right].$$

(1) When ζ is small, $z < 0$ and $|z|$ is large enough, then $a > 0$, $\Delta < 0$, and we have $\frac{\partial p}{\partial \theta_{SM}} < 0$. Because $p < \hat{\mu}$, we can obtain that $\frac{\partial CC}{\partial \theta_{SM}} = \frac{\partial p}{\partial \theta_{SM}} < 0$.

(2) When ζ is large, $z < 0$ and $|z|$ is large enough, then $a < 0$, $b < 0$, $c > 0$, $\Delta > 0$. So there is a unique root $\theta^*_{SM} \in [0, 1]$. When $\theta_{SM} \in [0, \theta^*_{SM}]$, we have $\frac{\partial CC}{\partial \theta_{SM}} \leqslant 0$; when $\theta_{SM} \in (\theta^*_{SM}, 1]$, we have $\frac{\partial CC}{\partial \theta_{SM}} > 0$. Therefore, the sector size effect has a non-monotonic impact.

- When $\frac{\theta_S\theta_M + (\theta_S+\theta_M)\left(\theta_S+\theta_N\frac{\hat{\sigma}^2}{\Sigma^2}\right)}{\theta_S+\theta_M+\theta_N\frac{\hat{\sigma}^2}{\Sigma^2}}\underline{z} \leqslant z < \frac{\theta_S\theta_M+(\theta_S+\theta_M)\theta_S}{\theta_S+\theta_M}\underline{z}$, the equilibrium price is a constant. Therefore, $\frac{\partial CC}{\partial \theta_{SM}} = 0$.
- When $\frac{\theta_S\theta_M+(\theta_S+\theta_M)\theta_S}{\theta_S+\theta_M}\underline{z} \leqslant z < 0$, the equilibrium price has the form in Equation (A4). Therefore, $\frac{\partial CC}{\partial \theta_{SM}} < 0$.
- When $0 < z \leqslant \frac{\theta_S\theta_M+(\theta_S+\theta_M)\theta_S}{\theta_S+\theta_M}\overline{z}$, the equilibrium price has the form in Equation (A5). So in this scenario, $\frac{\partial CC}{\partial \theta_{SM}} < 0$.
- When $\frac{\theta_S\theta_M+(\theta_S+\theta_M)\theta_S}{\theta_S+\theta_M}\overline{z} < z \leqslant \frac{\theta_S\theta_M + (\theta_S+\theta_M)\left(\theta_S+\theta_N\frac{\hat{\sigma}^2}{\Sigma^2}\right)}{\theta_S+\theta_M+\theta_N\frac{\hat{\sigma}^2}{\Sigma^2}}\overline{z}$, the equilibrium price is a constant. Then, $\frac{\partial CC}{\partial \theta_{SM}} = 0$.
- When $\frac{\theta_S\theta_M + (\theta_S+\theta_M)\left(\theta_S+\theta_N\frac{\hat{\sigma}^2}{\Sigma^2}\right)}{\theta_S+\theta_M+\theta_N\frac{\hat{\sigma}^2}{\Sigma^2}}\overline{z} < z$, the equilibrium price has the form in Equation (A6).

Note that the sign of $\frac{\partial p}{\partial \theta_{SM}}$ equals to:

$$\text{sign}\left[\frac{\partial p}{\partial \theta_{SM}}\right] = -\text{sign}\left(a\,\theta^2_{SM} + b\,\theta_{SM} + c\right),$$

where a, b and c are the same as in prior analysis.

(1) When ζ is small, $z > 0$ and $|z|$ is large enough, $a < 0$, $\Delta < 0$, and we have $\frac{\partial p}{\partial \theta_{SM}} > 0$. Because $p > \hat{\mu}$, we can obtain that $\frac{\partial CC}{\partial \theta_{SM}} = -\frac{\partial p}{\partial \theta_{SM}} < 0$.

(2) When ζ is large, $z > 0$ and $|z|$ is large enough, $a > 0$, $b > 0$, $c < 0$, $\Delta > 0$. So there is a unique root $\theta^*_{SM} \in [0, 1]$. When $\theta_{SM} \in [0, \theta^*_{SM}]$, we have $\frac{\partial CC}{\partial \theta_{SM}} \leqslant 0$; when $\theta_{SM} \in (\theta^*_{SM}, 1]$, we have $\frac{\partial CC}{\partial \theta_{SM}} > 0$. Therefore, the sector size effect has a non-monotonic impact.

In sum, the influence of sector size effect is contingent on both the market concentration level ζ and the absolute value of asset supply z. Specifically, when the absolute value of asset supply asset supply z is small enough, the cost of capital is decreasing with the sector size θ_{SM}; whereas when $|z|$ is large enough, the cost of capital has a negative relationship with θ_{SM} when the market is less concentrated, and it has U-shaped relationship when the market is highly concentrated.

Proposition 3.2 summarizes the results. ■