“Microstructure and Ambiguity”

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1. Introduction

A general goal for stock exchanges is to increase participation by firms and investors. There is a direct reason for doing so as exchanges make money off of trade executions and listing fees, and both of these are increased by greater participation. But there is also an indirect channel as more volume begets lower spreads, which lowers execution costs, which induces more volume, which then generates more profits. This cycle suggests that exchanges and investors alike gain from greater participation, and even the economy may benefit from increased participation in stock markets as it can lower the equity premium. How then to increase participation in a market?

We know from a growing body of research (see, for example, Gilboa and Schmeidler [1989]; Cao, Wang and Zhang [2003]; Easley and O’Hara [2005]) that a factor influencing participation is ambiguity aversion. Traders with ambiguity aversion opt not to participate when the ambiguity, or uncertainty, in a market is high. Such a problem arises when traders believe that adverse outcomes are possible, even when these outcomes are objectively very unlikely. In this paper, we look at how features of the microstructure can reduce ambiguity and thereby enhance participation in an equity market.

Linking microstructure to ambiguity seems particularly appropriate given that ambiguity aversion is often ascribed to naïve investors. For an exchange, attracting these naïve investors essentially adds uninformed order flow, and this in turn enhances the

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1 Exchange revenues arise from multiple sources. These include fees collected from members or specialists, regulatory fees, explicit execution fees, and tape revenue (income that arise from selling quote and trade data) which is often a substantial fraction of the exchanges overall revenue. These latter two sources of revenue are strictly increasing in volume, resulting in exchange profits being large volume driven.


3 Ambiguity aversion, also known as Knightian uncertainty, arises when traders distinguish between risk and uncertainty in their decision-making. When traders are unable to attach probabilities to the occurrence of particular outcomes, they purse decision-rules that maximize the minimum expected utility across possible states. This results in traders attaching undue importance to unlikely outcomes, and induces non-participation. See Gilboa and Schmeidler [1989]; Ghirardato, Maccheroni, and Marinacci [2004]; or Klibanoff, Marinacci, and Mukerji [2004] for greater analysis.
liquidity of the market. We develop a model with objective expected utility maximizing traders and ambiguity averse traders, and we show how these naïve traders can choose to participate or not participate in markets. We then show how specific features of the microstructure can reduce the perceived ambiguity, and induce participation by both firms and issuers. For our purposes here, we define the microstructure of the market as including market rules, trading systems, and trading procedures. Our analysis demonstrates how designing markets to reduce ambiguity can benefit investors through greater liquidity, exchanges through greater volume, and issuing firms through a lower cost of capital.

An immediate application of our research is to provide insights into the function and design of markets. The advent of technology has transformed the competitive landscape for stock exchanges from what was a relatively protected, monopolistic institution into a highly competitive, dynamic industry. This change has resulted in a plethora of trading venues, and it has forced exchanges to compete for issuers and investors alike. Our analysis shows the competitive role played by features such as listing standards, trading halts, and market rules and procedures. There is a large and important literature in microstructure looking at such issues (see, for example, Macey and O’Hara [1998; 2003]; Parlour and Seppi [2003]; Foucault and Parlour [2004]; Werner and Panchenoga [2004]; Chemmanur and Fulghieri [2005])), with much of this research focusing on how the microstructure affects the price discovery and liquidity production role of markets. Our work is the first that we are aware of to focus on the role and impact of market design in reducing ambiguity, or uncertainty, and we demonstrate how this added dimension can have important implications for market design.

Our analysis also demonstrates how firms may sort out between listed markets (stock exchanges), and between listed markets and unlisted markets such as the Pink Sheets. As we demonstrate, for some firms, the costs of exchange listing are more than

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4 Ahn, et al [2006] provide a careful empirical analysis showing the positive effects of greater small trader participation on market liquidity, execution costs, and trading volume in the Tokyo Stock Exchange.

5 These specific features could include listing rule (blue sky protection); delisting rules (fraud); trading halts; affirmative obligations of market makers (liquidity); transparency; price collars and daily limits; public comes first rules; clearing house rules and margin requirements; fast market rules, etc.

6 These market changes and their impact on exchanges are discussed in O’Hara [2004].
offset by the benefits arising from their increased attractiveness to investors, resulting in a lower cost of capital for the firm. For other firms, particularly those for whom ambiguity is either very high or very low, exchange listing brings few benefits. Our results here provide one explanation for why the Pink Sheets include such market titans as Nestle and Volkswagen, while also serving as the trading venue for virtually unknown firms such as Kahala Corporation and O’Sullivan Industries. Moreover, our results provide new insights into the complex issues surrounding domestic and international competition for listings, and suggest why “super listing requirements”, as have been implemented by several stock exchanges (see, for example, the Bolsa de Valores do Sao Paulo), may prove effective in inducing foreign investors to hold stocks in emerging economies.

Perhaps the most important result of our research is to demonstrate a new channel whereby microstructure matters for real economic variables. Researchers have increasingly argued that liquidity and information risk affect asset prices, providing an importance to the microstructure surrounding the trading of assets.\(^7\) In this research, we show how microstructure can reduce the ambiguity confronting traders, and how this, in turn, can affect asset prices and, by extension, a firm’s cost of capital. What underlies our analysis is the influence of microstructure variables on trader participation. As stressed by Campbell [2006], nonparticipation in equity markets is empirically large, and economically detrimental.\(^8\) Our analysis here develops one explanation for why this problem arises, and more importantly, provides a range of microstructure solutions for reducing it.\(^9\)

This paper is organized as follows. The next section provides a brief overview of ambiguity aversion, and its implications for decision making. Section 3 then sets out a

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\(^7\) For research linking liquidity to asset pricing, see Chordia, Roll and Subrahmanyam [2000] and Chordia, Sarkar, and Subrahmanyam [2005]. The role of information risk in asset pricing is found in Easley, Hvidkjaer, and O’Hara [2003]; O’Hara [2003]; and Easley and O’Hara [2004].

\(^8\) Researchers have proposed a variety of explanations for non-participation in markets, including incomplete information (see Merton’s [1987]), a lack of trust (Guiso, Sapienza, and Zingales [2005]), and a variety of behavioral causes (see Barberis and Thaler [2000] for a review of the behavioral literature on this topic). Analyses linking nonparticipation to ambiguity are given by Cao et al [2005], Easley and O’Hara [2004], and Dow and Werlang [1992].

\(^9\) Guiso, Sapienza, and Zingales [2005] provide an interesting analysis showing empirically that trust in stock markets, which they argue is not related to ambiguity aversion, affects participation. What engenders trust in their model is not specified, but it seems sensible that perceptions of greater market integrity, which are one outcome of our microstructure solutions, would alleviate also alleviate trust concerns and thereby induce participation.
model of trading which includes sophisticated (objective expected utility maximizing) traders, naïve (ambiguity averse) traders, and multiple trading venues defined by differing market microstructures. We solve for the respective traders’ demands in each market, and we provide conditions for participating (by the ambiguity averse traders) and nonparticipating equilibria. We also characterize equilibrium asset prices in each market. Section 4 characterizes the equilibrium, and demonstrates how firm and trader characteristics affect where firms list and their cost of capital. Section 5 considers some extensions and generalizations to the analysis, and in particular considers the structure of listing fees and standards, the competition between markets and listing venues, and the role of market rules and trading practices. Section 6 concludes by discussing more broadly the effects of microstructure and regulation on firms’ and investors’ decisions to participate in equity markets.

2. Ambiguity and Investor Behavior

Many households hold portfolios of assets that are inconsistent with expected utility maximization using correct expectations about returns. Campbell in his 2006 Presidential Address to the American Finance Association provides compelling evidence from various sources that a substantial fraction of households do not participate in equity markets and that many of those who do participate do not properly diversify their portfolios. There are several possible explanations for these failures to act as standard models imply. Some households could simply be making errors, some may be acting according to preferences or decision rules that are different from those we normally consider, some may have incorrect expectations, and some may be inexperienced and perhaps learn over time to improve their performance. Undoubtedly, a mixture of these and other stories are appropriate. In this paper, we model asset markets in which the behavior of some investors is consistent with standard expected utility maximizing behavior and the behavior of others is not.

Some of our investors are von-Neumann Morgenstern expected utility maximizers who know the return distribution for each asset. This rational expectations assumption for expected utility traders is a strong, but standard, assumption. The other investors are aware of all assets but they do not act as if there is single return distribution for each
asset. Instead they act as if there is a set of return distributions for each asset and they are unable or unwilling to place a prior on this set. The return distributions in this set reflect the uncertainty that some investors have about how the stock market works. These investors act as if they believe that both good and bad return distributions are possible, but they simply don’t have enough experience to know which distribution is correct or to place a prior on the set of conceivable return distributions. These investors are naïve or ambiguity averse investors.

The famous Ellsberg Paradox provides experimental evidence that some, but not all, individuals do not act as if they have a prior. In a simple version of the Ellsberg experiment an individual is given an opportunity to bet on the draw of a ball from one of two urns. Urn one has 50 red and 50 black balls. Urn two has 100 balls which are an unspecified mix of red balls and black balls. First, subjects are offered a choice between two gambles: $1 if the ball drawn from urn one is red and nothing if it is black or $1 if the ball drawn from urn two is red and nothing if it is black. Many subjects chose the first gamble. Thus, if they have a prior on urn two the predicted probability of red in urn two is less than 0.5. Next, subjects are offered a choice between two new gambles: $1 if the ball drawn from urn one is black and nothing if it is red or $1 if the ball drawn from urn two is black and nothing if it is red. Many subjects again chose the first gamble. Thus, if they have a prior on urn two the predicted probability of black in urn two is less than 0.5. This cannot be, so they do not act as if they have only one prior on urn two.

This Ellsberg Paradox led Gilboa and Schmeidler [1989] to weaken the standard expected utility axioms in order to produce a decision theory consistent with the behavior observed by Ellsberg.10 Their approach yields a Bernoulli utility function defined over payoffs but rather than a single prior it yields a set of priors. The axioms also imply that the decision maker evaluates any act according to the minimum expected utility it yields. In the Ellsberg framework this model implies that the individual acts as if he has a set of priors for urn two which includes a prior in which the probability of red is less than 0.5

10 Knight [1921] originally developed the notion of individuals making a distinction between known odds and uncertain or ambiguous odds. This distinction was noted by Savage [1954], but in his model of subjective expected utility it plays no role. The standard model of asset pricing is based on Savage’s foundation for expected utility maximization. The distinction between Knightian uncertainty, now known as ambiguity, and risk has seen resurgence due to the work of Schmeidler [1989] and Gilboa and Schmeidler [1989].
and a prior in which the probability of black is less than 0.5. Since he acts as if evaluates each act according to its minimum expected utility, he will never chose urn 2 as in his pessimistic view it will be unlikely to pay off.

The Gilboa and Schmeidler model has been generalized to allow for the possibility that the decision maker is not so pessimistic as to select the act that maximizes the minimum expected utility. Two recent papers by Ghirardato, Maccheroni and Marinacci (2004) and Klibanoff, Marinacci and Mukerji (2004) provide alternative approaches to separating ambiguity and the decision maker’s attitude toward ambiguity. We follow the Gilboa and Schmeidler model to illustrate our ideas, but the results could be easily modified using alternative models of ambiguity aversion.

There are, at least, two other reasonable ways to view the decision problem faced by our ambiguity averse decision makers. First, they could be thought of as choosing robust portfolios. That is, they could search for portfolios that are robust to their uncertainty about the correct model for returns. Hansen and Sargent (2000) follow this approach to evaluating macroeconomic models. Maenhout (2004) and Garlappi, Uppal, and Wang (2004) use a similar approach to consider asset pricing issues. Second, they could be thought of as behavioral traders who either have biased beliefs or who do not maximize expected, or minimum expected, utility. We prefer the ambiguity aversion approach as it is based on preferences for stochastic consumption streams and axioms about those preferences.

3. The Model

We analyze an economy with three assets. There is one risk free asset, money, which has a constant price of 1. There are two risky assets. All investors know that returns to the risky assets are independent and normal. But they do not necessarily know the mean or variance of these returns. The set of possible means for the return on asset i is \( \{ \bar{r}_i^1, ..., \bar{r}_i^N \} \); the set of possible variances is \( \{ \sigma_i^2, ..., \sigma_i^2 \} \). All pairs of mean and variance
are possible and we let $\Theta' = \{\theta_1', \ldots, \theta_n'\}$, with $n = N^2$ elements, be the set of possible return parameters.\footnote{As will become apparent only the minimum and maximum mean return and maximum variance affect decisions made by AA traders. So changes to the set $\Theta'$ that leave these values unchanged have no affect on the market. In particular, $\Theta'$ can be a continuum.}

There are $J$ investors indexed by $j = 1, \ldots, J$. All investors are ambiguity averse and they all have CARA utility for wealth, with the risk aversion parameter set equal to 1:

$$u_j(w) = -\exp(-w).$$

There are two types of investors in the economy, denoted S investors and U investors. Fraction $1 - \mu$ of the investors are sophisticated or experienced investors (S) who have rational expectations about return parameters. Let $(\hat{\mu}', \hat{\sigma}')$ denote the true value of the mean return and variance for asset $i$. Since our S traders have rational expectations they know $(\hat{\mu}', \hat{\sigma}')$, and hence actually face no ambiguity about the return distribution.\footnote{Allowing S traders to have a common prior over $\Theta'$, rather than knowing the true values, complicates the analysis without adding to the intuition.}

Fraction $\mu$ of the investors are unsophisticated investors (U). Unsophisticated investors also care about means and variances, but they differ from sophisticated investors in that they do not know the return parameters. Instead, they consider each normal distribution of returns, $N(\theta')$, as a possible return distribution. To make our analysis of the equilibrium interaction between S and U traders interesting we assume that U investors consider as possible mean returns above and below $\hat{\mu}'$ and variances above and below $\hat{\sigma}'$. That is, the true parameter values are convex combinations of the extreme values considered possible by the U traders.

Following Gilboa and Schmeidler’s (1989) axiomatic foundation for ambiguity aversion, we model ambiguity averse investors as choosing a portfolio to maximize their minimum expected utility over the set of possible return distributions. Sophisticated investors only consider the normal distribution with parameters $(\hat{\mu}', \hat{\sigma}')$ to be possible. So they act as if they are standard expected utility maximizers. Unsophisticated investors consider all normal distributions with parameters in $\Theta' = \{\theta_1', \ldots, \theta_n'\}$ to be possible.
The per capita endowments of money and assets are \((m, \tau^1, \tau^2)\). The exact distribution of this endowment over investors does not affect their demands for risky assets because of the CARA-Normal structure, so we do not specify it. We denote a typical investor’s wealth by \(w\). Where no confusion would occur, we will drop the investor index. The investor’s budget constraint is

\[
 w = m + p^1 x^1 + p^2 x^2
\]

(2)

where \(p^i\) is the price of asset \(i\), \(m\) is the quantity of money and \(x^i\) is the quantity of risky asset \(i\).

These two risky assets represent stock in two firms, 1 and 2. There are two stock markets, A and B, on which money and these assets can be traded. Each firm must chose on which market to list its stock. A stock can be listed on, and trade on, only one market (we relax this assumption in Section 5 and consider the consequences of cross-listings and non-listing trading privileges). If firm \(i\) lists its stock on market B, it pays no cost and the returns that stock owners receive are \(r^i\). If firm \(i\) lists its stock on market A, it pays a fee of \(c\) per share, which is deducted from the return that investors receive, and market A provides a certification service. This service has no value to sophisticated investors, but unsophisticated investors interpret it as guaranteeing that the minimum mean return on stock in firm \(i\) is \(r^i\) and that the maximum variance of returns on firm \(i\)’s stock is \(\sigma^i\). This changes the perceived set of return parameters to \(\Theta^i_A\), where in \(\Theta^i_A\) the minimum mean return is \(r^i\) and the maximum variance is \(\sigma^i\).

This certification service can be interpreted in several ways. First, it could be that market A investigates companies that apply to be listed on it and only agrees to list those which meet some minimum standards. For example, it may require that the company actually have assets, that it file audited statements about its returns, and that it meet a variety of corporate governance requirements. Alternatively, market A may oversee clearing and settlement to insure that a trader who buys stock actually receives it and that one who sells stock actually delivers it. Yet another dimension could be that the exchange monitors the trading process to ensure that trading is fair and non-manipulative. These services assure unsophisticated investors that some worst cases they imagined for the mean or variance of the return they receive do not occur. Note that we are not
assuming here that the certification ensures that the stock is a good investment. The actual investment outcome for a stock can be very good or very bad; what the certification role does is rule out “blue sky” outcomes where either the company or the trade will fail to exist, or behaviors so egregious that the trader is destined to be exploited.

We assume that firms care only about the equilibrium price of their stock, or equivalently about their equilibrium cost of capital. Each firm is thus assumed to list its stock on the market which provides the greatest equilibrium price for the stock.

Investors are allowed to go long or short in each asset. If the investor chooses portfolio \((m, x^1, x^2)\) his random next period wealth will be

\[
\hat{w} = m + (\bar{r}^1 - I^1 c)x^1 + (\bar{r}^2 - I^2 c)x^2,
\]

where \(I^1\) is 1 if firm \(i\) lists on market \(A\) and 0 otherwise.

For an objective expected utility maximizer, with CARA utility of wealth the expected utility of this random wealth is a strictly increasing transformation of

\[
(\bar{r}^1 - I^1 c - p^1)x^1 + (\bar{r}^2 - I^2 c - p^2)x^2 - 1/2 \sigma^1(x^1)^2 - 1/2 \sigma^2(x^2)^2 + w.
\]

Calculation shows that the sophisticated investor’s demand function for asset \(i\) is given by:

\[
x^*_i(p^i) = \frac{\bar{r}^i - I^i c - p^i}{\sigma^i}.
\]

An unsophisticated, ambiguity averse investor evaluates the expected utility of wealth for each parameter vector and chooses the portfolio that maximizes the minimum of these expected utilities. In effect, the U investor tries to avoid the worst case distributions of returns, and so chooses a portfolio that explicitly limits exposure to such adverse distributions. The expected utility of random wealth, given parameters \((\theta^1 = (\bar{r}^1, \sigma^1), \theta^2 = (\bar{r}^2, \sigma^2))\), is a strictly increasing transformation of

\[
(\bar{r}^1 - I^1 c - p^1)x^1 + (\bar{r}^2 - I^2 c - p^2)x^2 - 1/2 \sigma^1(x^1)^2 - 1/2 \sigma^2(x^2)^2 + w.
\]

Thus, the unsophisticated investor’s decision problem can be written as

\[
\max_{(x^1, x^2)} \min_{(\theta^1, \theta^2)} \left( (\bar{r}^1 - I^1 c - p^1)x^1 + (\bar{r}^2 - I^2 c - p^2)x^2 - 1/2 \sigma^1(x^1)^2 - 1/2 \sigma^2(x^2)^2 + w \right)
\]
where the minimum is taken over $\Theta^i_j$ if firm $i$ lists on market $A$ and over $\Theta^i$ if firm $i$ lists on market $B$.

Examining the minimization problem reveals that for any portfolio the minimum occurs at the maximum possible variance for each asset. This variance is $\sigma^i_{\text{max}}$ if firm $i$ lists on market $B$ or $\sigma^i$ if firm $i$ lists on market $A$. Whether the minimum occurs at the maximum or minimum mean return depends on whether the investor is long or short in the asset. The minimum occurs at minimum mean return for asset $i$ if the investor is long in asset $i$ and at maximum mean return for asset $i$ if the investor is short in asset $i$. Denote these mean returns by $\bar{\tau}^i_{\text{min}}$ and $\bar{\tau}^i_{\text{max}}$, respectively, if firm $i$ lists on market $B$ and by $r^i_c - c$ and $\bar{\tau}^i_{\text{max}} - c$, respectively, if firm $i$ lists on market $A$. Calculation shows that the unsophisticated investor’s demand function for asset $i$ is

$$x^i(p) = \begin{cases} \frac{\bar{\tau}^i_{\text{min}} - r^i_c}{\sigma^i_{\text{max}}} & \text{if } \bar{\tau}^i_{\text{min}} > p^i, I^i = 0 \\ 0 & \text{if } \bar{\tau}^i_{\text{min}} \leq p^i \leq \bar{\tau}^i_{\text{max}}, I^i = 0 \\ \frac{\bar{\tau}^i_{\text{min}} - r^i_c}{\sigma^i_{\text{max}}} & \text{if } \bar{\tau}^i_{\text{min}} < p^i, I^i = 0 \\ \frac{\bar{\tau}^i_{\text{max}} - r^i_c}{\sigma^i_{\text{max}}} & \text{if } \bar{\tau}^i_{\text{max}} < r^i_c, I^i = 1 \\ 0 & \text{if } r^i_c - p^i \leq \bar{\tau}^i_{\text{max}} - c, I^i = 1 \\ \frac{\bar{\tau}^i_{\text{max}} - r^i_c}{\sigma^i_{\text{max}}} & \text{if } \bar{\tau}^i_{\text{max}} > p^i, I^i = 1 \end{cases}.$$ (8)

There are several properties of this demand function that will be important for our analysis. First, note that if the price of asset $i$ is above the minimum possible mean net return and below the maximum possible mean net return, then the unsophisticated investor will not participate in the market for asset $i$.13 This occurs because an unsophisticated investor is heavily influenced by the worst possible state and what is worst depends on the investor’s asset position. Second, note that the unsophisticated investor’s decision about whether to hold the asset is independent of the set of variances he believes to be possible. All that matters for the participation decision is the price, the minimum mean net return and the maximum mean net return. If the unsophisticated

13 Here by not participating we mean that his final asset position will be zero. This interpretation is most natural if ambiguity averse investors do not initially hold the risky asset.
investor decides to hold the asset, then variance matters, just as it does for the sophisticated investor. But note that only the maximum possible variance affects the quantity to be held by an unsophisticated investor.

In equilibrium two conditions must be satisfied. First, the per capita demand for each asset $i$ must equal its per capita supply. Equating the demands from equations (5) and (8) to this supply then yields

$$\mu x^i(\hat{p}^i) + (1 - \mu) x^i(\hat{p}^i) = \bar{x}^i. \tag{9}$$

Second, each asset must be listed on the market which yields the greatest equilibrium price for the asset.

To construct the equilibrium, we determine the market clearing price for each asset if it is listed on market A and if it is listed on market B. Denote these prices by $p_A$ and $p_B$, respectively. Because these demands are complex, the equilibrium may also be complex. In particular, depending on the parameters of the economy, there are two possible types of solutions to the market clearing equation.

Consider market clearing for stocks listed on market B. First, if at a price between $\min i r$ and $\max i r$ the sophisticated investors are willing to hold the entire supply of the asset, then in equilibrium the unsophisticated investors will not participate in the market. If only $S$ investors participate in the market the market clearing price must be

$$\hat{p}_B^i = \bar{p}^i - \frac{\sigma^i}{\mu} \hat{r}_B. \tag{10}$$

Thus, $\hat{p}_B^i$ will be the market clearing price for asset $i$ listed on market B if $\min i r B \geq \hat{p}_B^i \geq \max i r B$. Note that $\max i r B \geq \hat{p}_B^i$ as $\max i r B \geq \bar{p}^i \geq \hat{p}_B^i$, so the binding condition is $\min i r B \geq \max i r B$.

Second, it is possible that both types of investors participate in the market for asset $i$. If we conjecture that both types of investors participate, then the market clearing price must be

$$p_B^* = \frac{\mu \bar{x}^i r_{\min} + (1 - \mu) \sigma^i_{\max} \bar{p}^i - \bar{x}^i}{\mu \sigma^i + (1 - \mu) \sigma^i_{\max}}. \tag{11}$$

This can be a market clearing price only if unsophisticated investors are willing to participate, i.e. only if $\max i r B < \min i r B$. Calculation shows that this constraint is met if and only
if \( \hat{p}_B^i < \bar{r}_{min}^i \). In order to insure that the price is sensible (greater than zero) even if there are only unsophisticated investors in the market, we assume that \( \bar{r}_{min}^i - x^i \sigma_{min}^i > 0 \).

As the binding condition for a non-participation outcome on market B is \( \hat{p}_B^i \geq \bar{r}_{min}^i \), one and only one of these prices will prevail. Thus, there is a unique market clearing price on market B. This equilibrium is either one in which unsophisticated investors do not participate, a Non-Participating Outcome, or one in which they do participate, a Participating Outcome.

The analysis for stocks listed on market A is symmetric. The only difference is that the cost \( c \) is deducted from returns, and minimum returns and maximum variances are drawn from \( \Theta_A' \) rather than \( \Theta' \). So the non-participating price on market A is \( \hat{p}_A^i = \bar{r}^i - c - \frac{\sigma_r}{\mu} \) and the participating price on market A is

\[
\hat{p}_A^i = \mu \sigma_r (\bar{r}^i - c) + (1 - \mu) \sigma_r (\bar{r}^i - c - \bar{x}^i \sigma_r \sigma_r) \mu \sigma_r + (1 - \mu) \sigma_r
\]

These results are summarized in the proposition below.

**Proposition 1:** In each market there is a unique market clearing price for asset \( i \).

**A.** If firm \( i \) is listed on market A then the market clearing price, \( p_A^i \), is either:

1. Non-Participating: If \( \hat{p}_A^i = \bar{r}^i - c - \frac{\sigma_r}{\mu} \geq \bar{r}^i - c \) then \( \hat{p}_A^i \) is the market clearing price; or
2. Participating: If \( \hat{p}_A^i = \bar{r}^i - c - \frac{\sigma_r}{\mu} < \bar{r}^i - c \) then \( p_A^i \) is the market clearing price.

**B.** If firm \( i \) is listed on market B then the market clearing price, \( p_B^i \), is either:

1. Non-Participating: If \( \hat{p}_B^i = \bar{r}^i - \frac{\sigma_r}{\mu} \geq \bar{r}^i - \frac{\sigma_r}{\mu} \geq \bar{r}^i - c \) then \( \hat{p}_B^i \) is the market clearing price; or
2. Participating: If \( \hat{p}_B^i = \bar{r}^i - \frac{\sigma_r}{\mu} < \bar{r}^i \) then \( p_B^i \) is the market clearing price.

A firm will list its stock where the price is highest. Thus, firm \( i \) chooses to list its stock on market A if \( p_A^i \geq p_B^i \), otherwise the stock of firm \( i \) is listed on market B. Note
that if firm I’s stock would be traded in a non-participating equilibrium on market A, then if it was listed on market B it would also be in a non-participating equilibrium. However, since \( \hat{p}_A^i < \hat{p}_B^i \) no firm would choose to list on market A if the outcome on market A was non-participating. So in equilibrium either the firm is listed on market A and unsophisticated investors participate, or it is listed on market B where both participation and non-participation are potential outcomes.

**Proposition 2:** The equilibrium price for stock i is:

1. \( \hat{p}_B^i \) if \( \hat{p}_B^i - \frac{\sigma^2}{\mu} \geq \tau_i^i \).
2. \( \max \{ p_A^i, \hat{p}_B^i \} \) if \( \tau_i^i > \hat{p}_B^i - \frac{\sigma^2}{\mu} \geq \tau_i^i \).
3. \( \max \{ p_A^i, \hat{p}_B^i \} \) if \( \tau_i^i > \hat{p}_B^i - \frac{\sigma^2}{\mu} \).

In the three cases above, case 1 corresponds to a non-participating equilibrium in market B. In case 2, the firm can choose between a participating equilibrium on market A and a non-participating equilibrium on market B. In case 3, it can choose between participating equilibria in either market. The participating equilibrium price on market A can be factored as follows

\[
p_A^i = \frac{\mu \hat{p}_B^i + \sigma^2 \tau_i^i}{\mu \sigma^2 + \sigma_i^i (1 - \mu)} - c = \hat{p}_A^i - c
\]

where \( \hat{p}_A^i \) is the price that firm i’s stock would sell for on market A if there was no fee. This means that in cases 2 and 3 a firm chooses to list on market A if and only if \( \hat{p}_A^i > \hat{p}_B^i + c \). Since \( \tau_i^i \geq \tau_{\min}^i \) and \( \sigma_i^i \leq \sigma_{\max}^i \) we clearly have \( \hat{p}_A^i \geq \hat{p}_B^i \). Thus, whether firm i chooses market A over market B depends on the economically reasonable calculation of whether the costs (c) exceed the benefits (the price increase before deducting the fee).

**4. Characterization of Equilibrium**

We now turn to understanding how firm characteristics and trader characteristics affect where a firm’s stock will trade. As demonstrated above, the microstructure of the
exchange can result in different stock prices for the firm, and consequently affect the resulting cost of capital for the firm. This attaches an importance to the listing decision for firms, investors and exchanges alike.

A. Firm characteristics and the listing decision

We first consider firms for which naïve investors face a high degree of uncertainty. A simple metric of this uncertainty is the difference between the beliefs of sophisticated investors regarding returns in this firm, and the corresponding beliefs of the naïve investors. Recall that the participation decision for naïve investors depends only on the price and $\overline{r}_{\text{min}}$, while the decision of sophisticated investors to go long or short depends only on the price and $\hat{r}$, so we first consider a case where $\hat{r} - \overline{r}_{\text{min}}$ is large. Relative to sophisticated investors, naïve investors find this a very unappealing stock, and so, should the firm list on Market B, only sophisticated investors will hold the stock and a non-participating equilibrium will arise.

Would such firms instead opt to list on Market A? If the ambiguity is large enough, the answer is no. If the ambiguity is high, even the certification services of market A may not be sufficient to induce naïve investors to hold the stock. For these firms, the market clearing price when the stock is held only by sophisticated investors is above the minimum mean return that unsophisticated investors believe Market A can provide. Thus, the only equilibrium in Market A is a non-participating one, which is also the equilibrium obtaining in Market B. But with no listing fee in Market B, it is optimal for the firm to choose the less expensive non-participating equilibrium and list on Market B.

Now consider the opposite case where the perceived ambiguity in mean returns is small. For these firms, naïve investors’ beliefs about mean returns are very close to the beliefs of sophisticated traders, and so their participation decisions may also be very similar. For small enough ambiguity, it may be the case that naïve investors will opt to participate even if the stock is listed on Market B. It is easy to demonstrate that should a participating equilibrium prevail in Market B, it will also prevail in Market A. But again, Market B is cheaper than Market A, so for firms with very little ambiguity about mean returns, Market B is the preferred venue.
This outcome need not arise for firms in the middle, those for whom ambiguity is not too large and not too small. These firms get a boost in share price from Market A’s guarantees which may be large enough to compensate for the cost of listing on A. A necessary condition for this to occur is that Market A’s guarantees induce the naïve to participate, whereas they would not do so if the stock lists on Market B. Note, however, that participation alone is not sufficient to ensure the supremacy of Market A. Because Market A charges firms to list, it can be the case that the stock price in Market B’s non-participating equilibrium is higher than it is in Market A’s participating equilibrium, and the firm chooses market B. This has implications for the optimal listing fees for exchanges to charge, an issue we will return to later in this paper.

Overall, our analysis predicts that firms will sort out between markets in a systematic way. Firms with either very little or a lot of ambiguity about mean returns will opt for the trading venue with no certification, but lower costs. Firms with moderate ambiguity will benefit from paying the listing fees to an exchange in return for the certification services the exchange provides. These effects can be illustrated by a simple example.

**Example:** Suppose that there is no ambiguity about variance, and that the effect of listing on market A is to increase the minimum mean return according to 
\[ \tau_i^L = \tau_{i,\min}^L + \alpha (\bar{r}_i^L - \tau_{i,\min}^L), 0 < \alpha < 1. \] That is, \( \alpha \) measures the effectiveness of the certification role on market A. In this case, the equilibrium price of stock i as a function of the minimum mean return perceived by unsophisticated investors is described by Figure 1.

**INSERT FIGURE 1**

Firms with very low \( \tau_{i,\min}^L \) will be listed on market B and will be held only by sophisticated investors. Firms with intermediate \( \tau_{i,\min}^L \) will be listed on market A and will be held by both types of investors. Firms with high \( \tau_{i,\min}^L \) will be listed on market B and will be held by both types of investors.

**B. Trader populations and listing decisions**
Our analysis above shows that firm characteristics will influence equilibrium listing decisions. We now consider a second factor that could affect the equilibrium, the composition of the trader population. In our model, fraction $\mu$ of traders are unsophisticated or naïve traders, while $1-\mu$ are sophisticated traders. How does the fraction of unsophisticated investors affect listing decisions?

Suppose we first consider the case where $\mu$ is small, or where all or nearly all investors are sophisticated. For such investors, the guarantees offered by Market A have no value, and these investors would be just as happy to trade on Market B. With few new investors induced to trade on Market A, there is little or no gain to the stock price, but the costs of listing remain. Consequently, no firm will pay the listing fee on Market A, and all firms will list on Market B.

Alternatively, if all, or nearly all, investors are unsophisticated ($\mu$ is near 1), then, if the stock is to be traded at all, equilibrium requires a share price low enough to attract unsophisticated investors into the market. Firms will list on market A if the increase in minimum mean return that A offers to investors is larger than the cost of listing on A. Otherwise, they will list on market B. Note, however, that if there are not enough sophisticated investors then the cost of capital the firm faces may be so high as to preclude having traded equity. We return to this issue later in the paper.

It follows that for intermediate populations of unsophisticated traders, the listing decision will depend upon the relative costs and benefits that arise in each market. The greater the preponderance of naïve traders, the more likely it is that exchanges will predominate. The greater the predominance of sophisticated investors, the more likely it is that alternative markets will prevail.

These effects are illustrated in Figure 2 in which we assume that there is no ambiguity about variance ($\sigma_{\text{max}}' = \sigma' = \sigma = \bar{\sigma}$) and that the certification provided by market A is price increasing when there are only naïve traders ($\tau' - c > \tau_{\text{min}}'$). We see that if there are not too many naïve traders ($\mu < \mu'$) the equilibrium on market A would be non-
participating and so market B would also be in a non-participating equilibrium. Thus for these low values of $\mu$ the firm lists on market B as paying market A generates no benefit. As we increase the fraction of naïve traders the equilibrium on B eventually switches to a participating equilibrium. At this point the equilibrium on market A would also be participating, but the cost of listing on A is greater than the small price increase that switching to market A would yield. Thus market B continues to dominate. Once we increase the fraction of naïve traders to $\mu^*$ the firm switches to market A. At this point the price increase that A offers is large enough to overcome the listing cost as the large fraction of naïve traders depresses the price that would be received on market B. For even larger values of $\mu$ market A clearly remains dominant. 14

5. Extensions, Generalizations, and Empirical Implications

Having established the role that ambiguity may play in equilibrium, we now consider extensions and generalizations to the basic model. As we show in this section, the results are robust to a variety of specifications, suggesting that ambiguity may play a large role in affecting market and trader behavior. We illustrate the importance of these effects by considering the implications of our model for listing standards and listing fees, the competition between markets, and the role of market trading rules and practices.

A. Listing standards and listing fees

The exchange in our model provides certification services that allay the fears of naïve investors regarding aspects of the firm and its trading. An interesting feature of these services is that they are asymmetric in that they need only deal with downside outcomes; ambiguity averse investors are not concerned with unlikely favorable outcomes. Listing standards are one mechanism exchanges can use for this purpose. Listing standards generally specify that firms must have a certain number of outstanding shares, must meet financial disclosure and governance requirements, must not be bankrupt or delinquent in SEC reporting requirements, must have audited financial statements, and must observe corporate formalities such as annual meetings and the like.

14 It is also possible to have the switch to market A occur for values of $\mu$ low enough so that a participating equilibrium on market B would never be chosen.
Such standards ensure that a functioning corporation exists and that there will be sufficient shares to ensure an orderly market.

What listing standards do not ensure, however, is that the firm is a good investment, or even necessarily a good company. Neither the NYSE nor the Nasdaq investigate firms as to their business plans or operations, they do not collect data on operating efficiency or performance, and there is no requirement for continued listing that firms make profits or provide adequate, or even positive, returns for their investors.

Thus, unlike rating agencies such as S&P or financial analysts who explicitly evaluate firm quality, stock exchange listing requirements only certify that firms are on-going concerns.

Such a certification role, as opposed to a signaling role, is exactly predicted by our ambiguity-based analysis. Listing in our model does not change the objective risk-return characteristics of the firm; the beliefs of sophisticated investors, who have such beliefs, are not changed when the firm lists. Consequently, the long-run performance of firms measured by accounting data should not be affected by where the firm lists. Because the beliefs of the ambiguity averse investors change, however, the firm’s stock price is affected by their increased participation, and so listing should be accompanied by a positive price change. Another empirical implication of our ambiguity-based theory is that listing should increase the number of shareholders in the stock.

An alternative view of stock exchanges is that they do perform a signaling function, allowing investors to sort out the good stocks from the bad stocks. Chemmaneur and Fulghieri (CF) [2005] investigate such a role in a model analyzing a new firms’ choice between exchanges to list their equity. Their analysis focuses on asymmetric information between firms and investors, where some investors can gather information cheaply and other investors face higher costs. Exchanges in this model do not actually set prices, however, as the price is set by the entrepreneur. What exchanges do is provide an investor base (investors in their model are assigned to a specific exchange), and a signal to investors of firm quality. An interesting implication of this model is that firms listing on “higher quality” exchanges should have higher returns.

Our model does not include asymmetric information, and so we not address many of the interesting issues considered by CF. We note, however, that the signaling role
envisioned there is more akin to the role played by underwriters than by exchanges. In particular, underwriters have a due diligence requirement to investigate firms, while as noted above, exchanges do little beyond enforcing general requirements across all listed firms. Whether this is informative to investors as to the firm’s prospects is an empirical question, but to our knowledge it has not been shown that listing standards are actually predictive of future firm performance. Nonetheless, it could well be that listing activities address both ambiguity issues and asymmetric information issues, providing a double importance to the role of microstructure.

Turning now to listing fees, we have modeled listing fees as a per share charge the company pays which is then deducted from the per share returns provided to investors. The advantage of this specification is that it captures the salient feature of actual markets that larger companies pay higher overall listing fees. An alternative specification is to assume that a company pays a fixed charge to list, or some combination of a fixed charge and a per share charge. It is easy to show that the results of our analysis still hold provided the overall cost of listing is not too high.

Current market practices involve an up front listing fee and a continuing fee. The continuing fee schedule is increasing in size, but it is capped, resulting in larger companies paying disproportionately smaller fees per share. In our model, declining listing fees per share make it more likely that large firms will list on Market A and small firms on Market B. Such an outcome is consistent with listing patterns in the U.S., where the median size firm on the Pink Sheets is several orders of magnitude smaller than firms listed on the exchanges or the Nasdaq.

Our model also assumes that fees are exogenously set at c. Endogenizing listing fees introduces a number of interesting dimensions to the analysis. In the simplest framework where exchanges compete only for listing revenue, listing fees should equal the cost of providing certification services. To the extent that such services involve a large fixed cost, then larger markets can offer services more cheaply, and listings would be expected to consolidate only on large venues. Such an outcome is descriptive of U.S.
markets, where now only the Nasdaq, the NYSE, and the American Stock Exchange actively list stocks.15

A more realistic scenario is to recognize that an exchange is actually a multi-product firm, producing revenues from both listings and trading. Foucault and Parlour [2004] analyze decision-making of a vertically integrated exchange that competes for IPO listing by choosing both the level of its listing fees and its trading fees (via its choice of trading technologies). These authors argue that entrepreneurs listing decisions will depend upon both listing fees and trading costs, and they demonstrate that exchanges may choose different trading technologies to relax competition for listings.16 An interesting result in this model is that low trading cost exchanges can charge higher listing fees.

Our model does not explicitly include technology, but it does have implications for the trading costs facing investors. Listing services are valuable to firms in our model because the enhanced participation it engenders raises a company’s stock price. With more investors holding the stock, trading volume would also be expected to increase, as there are more traders who can be subject to liquidity shocks and the like. Because trading costs are generally scale-driven, the greater is the trading volume the lower is the cost, and so participation would endogenously influence trading costs. Showing these effects explicitly in our analysis would require adding additional trading periods, and explicit liquidity shocks affecting traders, but the overall impact would be to increase the advantages accruing to exchanges better able to induce participation via their certification process. Thus the trade-off between listing fees and trading costs demonstrated by Foucault and Parlour [2004] is even more likely to arise when participation effects are considered.

15 An interesting development in equity markets is the entrance of ArcaEx, the electronic trading platform formed by the merger of the Archipelago ECN and the Pacific Stock Exchange, into the listings business. Much of their focus appears to be on dual listing stocks listed elsewhere as their listing requirements note that “If the issuer was approved for listing [on another exchange] within the last twelve months, ArcaEx will accept a copy of the application and all supporting materials.” As ArcaEx is set to merge with the NYSE, whether ArcaEx retains a separate listing business remains to be seen. For more information on ArcaEx listing requirements see www.arcaex.com

16 Vertical integration is most applicable if where a stock trades is dictated by where a stock lists. While this was traditionally the case in equity markets, the rise of alternative trading venues, combined with increased competition between exchanges, has severed this link for many stocks. We discuss these issues more fully later in this section, but we note that if listing and trading are separable then the listing fee decision need not be linked to trading costs.
Markets may differ with respect to how well they can perform this certification function, providing the potential for monopoly rents to exchanges. The listing fees of the NYSE are substantially above those of the Nasdaq, reflecting a “premium” that firms pay to list on a higher quality market. Whether such listing fee differences reflect actual market quality differences, however, is increasingly coming into question, engendering substantial competition between exchanges for listings. What is very real is how important listing fees are as a revenue source for exchanges. For the NYSE, for example, listing fee revenue constitutes more than a third of the exchange’s total revenues, a figure substantially higher than the 13% of revenues listing fees averaged across exchanges world-wide in 2004.17

B. Competition between markets

Our model assumes that a firm must list and trade on only one market. While useful from a modeling perspective, actual markets are often more complex, raising a range of issues regarding competition between markets. We now consider how our analysis changes if listing and trading decisions can be more complex.

As useful preliminary, we note that in the U.S. firms traditionally list on only one market. Moreover, firms that list on the NYSE, the AMEX, or the Nasdaq do not simultaneously trade in the unlisted markets such as the Pink Sheets or the OTC Bulletin Board. However, the advent of unlisted trading privileges (denoted UTP) has resulted in firms listing on one exchange (for example the NYSE) and trading simultaneously on several exchanges and markets (such as the regional exchanges and the Nasdaq). Moreover, the rise of alternative trading systems (ATSs) and electronic communications networks (ECNs) has resulted in a plethora of trading venues that offer trade execution but do not list stocks. This decoupling of listing and trading is one of the most important changes occurring in equity markets, affecting virtually all aspects of exchange operation and regulation.

In our model, we consider a market which provides certification services and charges a listing fee (Market A) and a market that does neither. Such a framework

captures well the distinction between the NYSE (or the Nasdaq) and the Pink Sheets, where stocks listed on the NYSE never trade in the Pink Sheets, and stocks trading in the Pink Sheets pay no listing fees to do so. But there is also competition between the NYSE and the Nasdaq for listing stocks, and between these markets and global venues such as the London Stock Exchange and Euronext. How does such competition affect the listing decision?

To address this concern, consider two locales both offering certification and listing services. If Market A provides listing services for a company, then Market B may be able to free ride on the certification provided by A. Indeed, if the fact that a stock is listed on Market A is enough to change the beliefs of unsophisticated traders, then Market B could offer to dual list a stock listed on Market A at no charge. This would retain a high stock price for the issuing firm, but induce trading to flow to Market B, where the resulting execution and trading fees would increase Market B’s profitability at the expense of Market A. The Deutsche Borse’s waiver of listing fees to international firms listed elsewhere typifies such a strategy, as does the Nasdaq market’s offer of free cross-listing to any Dow – Jones Index stocks listed on the NYSE.

Such a competitive outcome illustrates a problem common to equilibria based on information production. Once Market A has certified firm quality, free-riding by other exchanges is a natural result. The immediate impact of this free-riding is on where trades execute, as competing venue can now take trading volume away from Market A without detrimental effects on the firm’s price. Two-part pricing strategies linking listing fees to execution revenues (as suggested by Foucault and Parlour [2004]) now become problematic as listing and trading decouple. Moreover, the ability of Market A to charge premium rents for certification is questionable if even knowing that a firm can qualify for listing is enough to allow a lower-priced exchange to list the stock successfully. The general decline of listing fees world-wide may reflect just such pressures.

A general solution to free-riding problems is to treat certification as a “public good”, and move listing from the individual exchanges to the regulator. Another factor

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18 See Parlour and Seppi [2003] for an interesting analysis of competition between trading venues.
19 Such a shift occurred in the United Kingdom where listing and delisting decisions were transferred from the London Stock Exchange to the Financial Services Authority, the “super-regulator” of the British capital and banking markets.
mitigating this breakdown is broadening the certification process to include elements more normally associated with the trading process. For ambiguity averse traders, uncertainty connected with the trading process may be just as important an influence on their participation as is uncertainty connected with firm characteristics. This suggests that exchanges may compete for ambiguity averse investors via the structure and design of market rules and practices.

C. Market Rules and Trading Practices

In our model, exchanges change beliefs of ambiguity averse investors by assuring these investors that some worst cases they imagined for the mean or variance of the return they receive do not occur. One such concern may arise with respect to clearing and settlement of the trade, as an investor may fear that the counterparty simply takes his money and the investor gets nothing in return. Margin rules are one mechanism exchanges use to deal with such problems, but trading systems use a variety of means to deal with counterparty default. For example, Ebay initiated a “PayPal buyer protection plan” to reduce uncertainty about settlement on their trading platform.

Another concern of naïve investors may be that they can be taken advantage of by market professionals. For example, traders may fear that brokers will execute their trades only when it is in the interest of the broker, and not in the interest of the customer, or that brokers will trade in advance of the customer order, thereby removing or reducing the investor’s gain on a trade. Similarly, traders may fear that specialists will set bid and ask prices to exploit a trader’s desire to buy or sell rather than quote prices that reflect an asset’s true value. Other concerns may relate to dealers either being unwilling to trade with customers when they wish to sell, or alternatively coercing traders to buy stocks which are destined to be poor investments.

Exchanges and trading venues deal with these issues in a variety of ways. Virtually all equity markets and exchanges have a “Know your customer” rule that imposes a suitability requirement on exchange members and brokers. Suitability requires brokers to recommend only those investments suitable for the investor’s objectives, rather than those that maximize the broker’s income.20 Similarly, exchanges (and regulators)

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20 For a discussion of suitability requirements and ambiguity see Easley and O’Hara [2005].
typically impose a duty of best execution on members to ensure that the customer trades at the best price available. Exchanges also generally forbid “front-running” by exchange members, thereby protecting the time priority of the investor’s order. The NYSE has a variety of rules to curtail specialist behavior, including an “affirmative obligation” to act as a counterparty at a reasonable price whenever a customer wants to trade; a “public comes first” rule which precludes the specialist from disadvantaging a public order; and a price continuity rule which limits how much the specialist can change his quoted prices. All of these trading rules work to reduce the ambiguity attached to “worst case” scenarios, and thus induce investors to participate in the market.

Naïve investors may also fear that they will be taken advantage of by other market players, and exchanges can counter these fears with particular trading practices. For example, traders may fear that company insiders will sell ahead of public news, leaving the naïve trader holding the now depreciated shares. Trading halts that preclude trading until events are publicly clarified can address these concerns. Similarly, investors may fear the stock price could be manipulated by speculators, who then profit at the naïve investors expense. Exchanges invest heavily in stock watch and trade monitoring systems to preclude exactly such behaviors. Naïve investors may even fear that “animal spirits” or irrational herding will cause prices to fall so rapidly that the market can collapse; circuit breakers, limit moves, and price collars are all trading practices that can address these concerns.

The examples given above illustrate the important role that trading rules and practices can play in ruling out aberrant outcomes that concern ambiguity averse investors. A cursory review of an exchange rule book reveals myriad rules and requirements, some so arcane as to be rarely, if ever, actually binding in practice. Yet, such obscurity is perfectly consistent with the ambiguity-resolving role detailed above; ruling out potential outcomes, even those that have virtually no chance of actually ever

21 EBay presents an interesting example of the challenges connected with the integrity of items sold by sellers to buyers on their system. The incidence of counterfeit goods on EBay has increased dramatically, which, along with angry buyers, has also precipitated a law suit by Tiffany & Company accusing EBay of facilitating the trade of counterfeit goods. EBay argues that it is only an auction facilitator, and so under no obligation to ensure integrity. Our ambiguity-based analysis, however, suggests that uncertainty over product characteristics should induce non-participation, an undesirable outcome for any trading system. For more discussion, see “Seeing Fakes, Angry Traders Confront EBay,” New York Times, January 29, 2006, pg. 1.
occurring, is what reduces ambiguity and thereby induces participation. As a consequence, market design may play an important role not only in affecting risk and return, but uncertainty as well.

### 6. Conclusions

This paper has demonstrated the potential benefits to exchanges, investors and firms from reducing ambiguity. Ambiguity over how markets work or asset prices are formed can cause some traders to be overly influence by “worst case” outcomes, even when these outcomes have little objective possibility of occurring. This, in turn, can cause such naïve investors to opt not to participate in markets, a result detrimental to both markets and the economy alike. As we have demonstrated here, microstructure features can be used to reduce this ambiguity, and thereby induce greater participation in markets. Because traders will gravitate to markets where uncertainty is lower, microstructure can play an important role both in the competitiveness of markets and in the overall determination of risk premia.

While the participation-based issues we have addressed here are an important concern for large companies, they may be even more important for small companies. Large companies are often held by institutional investors, who surely are much better described as sophisticated investors. Moreover, large companies are often older, have greater public information, are followed by financial analysts, and have greater familiarity to consumers, all features that might be expected to reduce uncertainty for investors. This is not the case for many small firms. Institutions often eschew holding small companies, in part because of the difficulty of amassing (or trading out of) large positions. Moreover, even finding information on small firms can be difficult, limiting the number of investors who could be sophisticated. The active role played by private equity firms in financing small, fledgling firms is consistent with this difficulty in finding knowledgeable investors. Indeed, if uncertainty regarding a firm is too high, then private equity may be the only recourse to obtain investment capital.

Small firms that do have public equity are often unable to meet the scale-related listing requirements of the exchanges, and so must trade in over-the-counter venues such as the Pink Sheets. Here the microstructure issues we have described take on particular
relevance, as many individual investors will simply not invest in a stock that is traded on the Pink Sheets.\textsuperscript{22} Such reluctance is understandable for, as discussed in Easley and O’Hara [2005], a perplexing feature of U.S. securities market regulation is that listed firms face much more stringent regulations than unlisted firms, resulting in the least investor protection for these unlisted firms.\textsuperscript{23}

Recently, the Pink Sheets have proposed changes to differentiate firms listed on the Pink Sheets into quality tiers. The “Premier QX” stocks will include companies large enough to be listed on a major exchange, with audited financial reports and annual shareholder meetings. Smaller companies with audited financials will be in the next tier, and all other stocks in the lowest tier.\textsuperscript{24} Such changes are consistent with our analysis here, where we have argued that certifying firm quality to investors can induce participation if it lowers ambiguity enough. It remains to be seen whether the relatively modest changes proposed can accomplish this task.

Our analysis may also have particular relevance for issues connected with financial market development. A growing literature (see, for example, Bekaert, Harvey, and Lundblad [2001; 2005]) suggests that economic growth may be linked with financial market development, raising the issue of how to induce participation in a country’s financial markets. Here the role of ambiguity seems particularly significant, as even sophisticated investors elsewhere may feel naïve when it comes to investing in unfamiliar settings. Microstructure can play a role by reducing this uncertainty. As we have argued, trading practices, trading procedures, and market rules all play a role in reducing potential “worst case” outcomes, and this may allow participation that otherwise would not occur.

A particular implication of our analysis is that countries (or markets) competing for investors need to place greater restrictions to rule out downside outcomes. An example of

\textsuperscript{22} Such views are reflected in the statement of Gerald Laporte, Securities and Exchange Commission, “A lot of people think of the Pink Sheets as a pejorative term. That’s not good for the market. We need to clear up the Pink Sheets so that small companies have a trading platform that is more viable”. See “Pink Sheets Aims for Respectability Under Ex-Trader”, Wall Street Journal, Dec. 17, 2005.

\textsuperscript{23} Legally, the Pink Sheets are not actually a stock exchange or a stock market, but rather a SIP, or securities information processor (see Macey, Pompilio, and O’Hara [2004] for discussion). As a SIP, firms trading on the Pink Sheets are not subject to many SEC requirements for public companies such as Sarbanes-Oxley requirements.

\textsuperscript{24} Cromwell Colson, CEO of the Pink Sheets, noted “I am trying to wade in, pull the good ones out of the drudge, and let the drudge get drudgier”. See op cit, WSJ, Dec. 17, 2005
this approach is the “super listing standard” successfully employed by the Bolsa de Valores do Sao Paulo to attract listings and investors to Brazil. Yet, stock exchanges alone may not be able to overcome the ambiguity facing investors due to uncertainties connected with a country’s legal and regulatory system. Addressing ambiguity at this level may be even more important for inducing participation in emerging markets.

Finally, we note that a natural concern with our analysis is whether ambiguity, *per se*, is actually an important influence in actual markets. We believe that it is, reflecting our view that the complexity of markets places heavy demands on investing agents, resulting in oft-observed behaviors that are inconsistent with the predictions of more standard models. And we note that the disparity of participation and diversification across investor groups is consistent with the naïve-sophisticated investor divergence we have modeled here. Other authors, such as Guiso, Sapienza, and Zingales [2005] argue that participation may result from non-ambiguity aversion related behavioral causes such as “trust”. Similarly, transaction costs combined with asymmetric information can also surely influence the ability of agents to access markets. Our own view accords a role to such causes, but we argue that there is a distinctive role played by ambiguity as well.

The debate over uncertainty, or ambiguity, has a long history in economics, and the resurgent interest in ambiguity is unlikely to resolve such a long-standing debate. What may help decide the issue, however, is whether ambiguity-based analyses provide insights into market behaviors in new and meaningful ways. We hope our analysis here provides a step in that direction.

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25 Huddart, Hughes, and Brunnermeir [1999] provide an excellent analysis of the role of disclosure standards in affecting international cross-listing.
This figure shows how a firm’s stock price, $p$, depends upon ambiguity averse investors’ minimum mean return and the trading venue. Market A provides a certification service and charges a listing fee, whereas Market B provides no certification and charges no fee.
Figure 2
Stock Prices and Trader Populations

This figure shows how changing the fraction of naïve investors, \( \mu \), affects a firm's stock price when it lists on Market A (with certification services) and on Market B (without certification services).
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http://home.uchicago.edu/~lhansen/wanting.pdf


