Disclosure Requirements and Stock Exchange Listing Choice in an International Context†

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We use a rational expectations model to examine how public disclosure requirements affect listing decisions by rent-seeking corporate insiders, and allocation decisions by liquidity traders seeking to minimize trading costs. We find that exchanges competing for trading volume engage in a "race for the top" whereunder disclosure requirements increase and trading costs fall. This result is robust to diversification incentives of risk-averse liquidity traders, institutional impediments that restrict the flow of liquidity, and listing costs. Under certain conditions, unrestricted liquidity flows to low disclosure exchanges. The consequences of cross-listing also are modeled.

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1. Introduction

1.1 Synopsis

Some maintain that if the Securities and Exchange Commission (SEC) were to permit stock exchanges to set their own disclosure standards, "a race for the bottom"[1] would ensue such that exchanges would lower their standards to attract new listings from abroad.[2] In turn, this behavior would result in higher trading costs to liquidity traders since market makers would widen their spreads so as to avoid expected losses on trades with insiders, who enjoy a greater information advantage in a low disclosure regime. However, there is a flaw with this line of reasoning: It implicitly assumes liquidity traders are unable to allocate their demands to the exchanges and firms of their choice.

In this paper, we investigate the consequences of exchange-determined disclosure standards in an adaptation of Kyle's (1985) model of strategic trading by insiders who receive private information prior to placing market orders. Liquidity traders choose where to trade and in what firms. An insider at each firm controls the listing decision for that firm. Each insider seeks to exploit his information advantage, while each liquidity trader seeks to allocate his exogenously generated demands over exchanges and firms so as to minimize trading costs. Market makers anticipate the possibility that information drives trading and set prices so as to break even in expectation. We distinguish between exchanges according to the precision of the public signals which they require as a condition of listing.

When liquidity traders are risk-neutral and unrestricted in allocating their demands over stocks and exchanges, they trade only in firms listed on the high disclosure exchange, where insiders' information advantage is less. In turn, insiders only concerned with expected gains to trade list on the high disclosure exchange to exploit the disguise afforded

[1] The phrase "race for the bottom" was coined by William L. Cary (1974) who, concerning the competition for corporation fees and franchise taxes, wrote (p. 701) "The first step is to escape from the present predicament in which a pygmy among the 50 states prescribes, interprets, and indeed denigrates national corporate policy as an incentive to encourage incorporation within its borders, thereby increasing its revenue." Alford, Jones, Leftwich and Zmijewski (1993) use this phrase to characterize the SEC's concern about the consequences of global competition by stock exchanges in setting listing requirements.

[2] Recently, this concern surfaced in a forum during which representatives of the US Securities and Exchange Commission (SEC) and the New York Stock Exchange (NYSE) debated whether foreign companies should be obliged to meet the same requirements as domestic companies (Bayless et al., 1996).

by the greater depth on that exchange. Competition between exchanges for either listings or liquidity leads exchanges to set listing requirements that mandate public disclosures approaching sufficient statistics for insiders' information about firm value, and thereby dissipate insiders' expected profits. These results apply a fortiori if other factors cause individuals who control the listing decision to seek liquidity rather than gains to insider trading.

We refer to the above as the benchmark case. To explain the existence of low disclosure exchanges on which some firms elect to list, we consider three possible candidates. First, we introduce risk aversion on the part of liquidity traders. The idea is that risk-averse liquidity traders have incentive to diversify by allocating some of their demands to firms listing on the low disclosure exchange despite the greater informational disadvantage. As a consequence, insiders may choose to list on a low disclosure exchange thereby exploiting that diversification incentive. Such choices, in turn, could motivate an exchange to choose a low disclosure standard. While this is an appealing argument, our analysis does not support the listing decision. Rather, the marginal firm prefers to follow the larger allocation of liquidity to the high disclosure exchange. Next, we introduce constraints on the liquidity that can be allocated to a foreign exchange. Such constraints are motivated by institutional impediments including taxes and other frictions that trap liquidity within national boundaries. While trapped liquidity explains listings on the low disclosure exchange, competition between exchanges, nonetheless results in a race for the top. Last, we switch from factors that only indirectly influence listing decisions by operating on liquidity, to a factor that directly affects those decisions, namely, listing costs. Given that insiders have an endowed position in the firm's securities, they bear a portion of the costs of meeting higher disclosure standards. These costs present insiders with a tradeoff between avoiding such costs and retaining more of their informational advantage versus following liquidity to the high disclosure exchange. Once again, the liquidity effect dominates and, in the absence of trapped liquidity, all firms list on the high disclosure exchange.

The model also serves to illustrate the consequences of cross-listing. When all liquidity is trapped by exchange, the proportion of firms cross-listing increases in the liquidity trapped on the low disclosure exchange. Many firms cross-list when the precisions of signals on the two exchanges are similar. In some cases all firms cross-list. An interpretation of this result is that allowing cross-listing is one way for low disclosure exchanges to attract firms. However, the low disclosure standard then is moot since firms must choose high disclosure to cross-list.

1.2 Principal antecedents

In related research by Admati and Pfleiderer (1988), Foster and Viswanathan (1990), and Bushman et al. (1997), the central issue is the allocation over time of informed and uninformed order flow in a single security. In contrast, trade in many securities on multiple exchanges is simultaneous in our work. Under Admati and Pfleiderer's initial assumption of all-or-nothing allocations by period for a single firm where private information is short-lived, they find all liquidity is allocated to a single period, whereas given no trapped liquidity, we find that all liquidity is allocated to a single exchange.[3] In equilibrium our liquidity traders seek to allocate their demands over firms in identical proportions. Intuitively, each liquidity trader lowers his expected trading cost by mimicking the aggregate anticipated allocations of the other liquidity traders.

Chowdhry and Nanda (1991) consider situations where a single security trades in several locations simultaneously and where some liquidity traders are able to choose their trading venue. Their "winner takes most result" is similar to "flocking" in our context. Their finding that "cracking down" on insider trading attracts liquidity is similar to our finding that liquidity traders prefer to trade on high disclosure exchanges. Our analysis differs from theirs because we allow liquidity traders to allocate trades over many firms listed on different exchanges. Furthermore, we endogenize the listing choice for each of these firms. Finally, we focus on the consequences of varying disclosure levels on listing decisions and allocations of liquidity, rather than on the informativeness of price.

Another study which considers effects of risk aversion on liquidity traders' decisions is Spiegel and Subrahmanyan (1992). Their liquidity traders, or "hedgers", condition their

[3] Were we to assume that allocation choices are all-or-nothing by firm, trade would take place in a single firm on the high disclosure exchange.

demands on random endowments of risky shares. They assume that hedgers' decisions take the form of a constant times their endowment. In equilibrium this constant is negative meaning that hedgers scale down their endowment in order to reduce risk. Similar to this paper, there is a tension between trading costs, which are minimized by electing not to trade, and risk, which is minimized by undoing their endowed position. The key modelling differences in the treatment that follows are the assumptions that liquidity traders must trade pursuant to random demand shocks, and that listing decisions by corporate insiders and disclosure standards set by exchanges determine trading costs.

The implication of our analysis that competition for trading volume leads toward full disclosure is similar to Verrecchia (1983), but the forces producing our results and Verrecchia's are very different.[4] In Verrecchia's setting, managers, seeking to maximize the current market value of their firms, disclose their private information to separate from lesser types. In our model, insiders, seeking to profit from their private information, list on exchanges requiring the highest level of disclosure, even though disclosure reveals some of their private information. Moreover, listing decisions in our model may precede acquisition of private information, while in Verrecchias' model disclosure decisions follow acquisition.

The remainder of this paper is organized as follows: section 2 presents our basic model; section 3 analyzes liquidity traders' allocation decisions, firm listing decisions, and equilibrium exchange disclosure standards in the benchmark case; section 4 analyzes cases in which either liquidity traders are risk-averse, liquidity is trapped by exchange, or insiders face listing costs; section 5 considers the consequences of cross-listing, and insider trading prohibitions; and, section 6 concludes the paper.

[4] We are grateful to Kerry Back for this point.

2. Model

We consider a setting in which there are two stock exchanges, indexed by $e = 1, 2$, with distinct disclosure standards; M firms and an insider for each firm who controls the exchange listing choice and who seeks to maximize expected gains to foreknowledge of end-of-period firm value, $v_m, m \in \{1, \ldots, M\} \equiv M$; N liquidity traders, each of whom allocates an exogenously generated demand in shares,[5] $u_n, n \in \{1, \ldots, N\} \equiv N$, over firms so as to minimize expected trading costs;[6] and a market maker for each stock on each exchange who, having observed the aggregate order flow, y_m, sets a price so as on average to break even.

Our model does not explicitly incorporate liquidity traders' preferences or the sources of their demands. We also leave unmodeled the mechanism by which liquidity traders take positions in stocks listed on domestic and foreign exchanges. A liquidity traders might trade through a broker on the exchange where the stock is listed, trade depository receipts in his home market, or buy and sell shares of a mutual fund which, in turn, trades on the exchange where the stock is listed. To the extent trading by institutions, such as pension and mutual funds, is driven by demand shocks realized by beneficiaries and retail customers, then such institutions are simply mechanisms for aggregating liquidity traders' demands that nevertheless are presented to market makers simultaneous with insiders' trades. What is crucial is that liquidity traders (and the managers of the institutions through which they invest) be sensitive to the magnitude of price adjustments made by the market maker in the face of informed trading by insiders. Because liquidity traders can allocate demands over exchanges and stocks, they allocate as much trading as possible to stocks and exchanges for which those costs are least. Making liquidity traders' demands contingent on price would complicate the analysis without altering this incentive.

[5] In keeping with the usual assumption in the literature on discretionary liquidity trading, demand shocks are denominated in shares of stock. The extension to generic shocks that can be realized in shares of many firms should not be too discomfiting given the further assumptions that firms are identical and allocations are made ex ante. Of course, the ex ante allocation is also commonplace as a stylized characterization of price-taking liquidity traders' behavior.

[6] In section 4.1, we consider the case where liquidity traders are risk-averse.

We assume firm values are normal, independent, identically distributed (NID) with prior mean $\bar{v}$; and variance σ_v^2, i.e.,

$$v_m \sim NID(\bar{v}, \sigma_v^2), \quad \text{for } m \in M,$$

liquidity demands are distributed

$$u_n \sim NID(0, \sigma_u^2), \quad \text{for } n \in N,$$

public signals are defined as firm values plus noise,

$$\theta_{em} = v_m + \epsilon_{em}, \quad \text{where } \epsilon_{em} \sim NID(0, \sigma_{\epsilon e}^2) \text{ for } e \in \{1,2\} \text{ and } m \in M,$$

and, the random variables $\{v_m, u_n, \epsilon_{em}\}$ are uncorrelated. The mandated precision of the public signals is our notion of disclosure standards. We assume θ_{1m} is a strictly sufficient statistic for $\{\theta_{1m}, \theta_{2m}\}$ with respect to v_m, for $m \in M$. Accordingly, we will refer to exchange $e = 1$ as the high disclosure exchange and $e = 2$ as the low disclosure exchange. Finally, we rule out perfect information by assuming that $\sigma_{\epsilon 1}^2 > 0$.

The order of play is as follows: exchanges choose their disclosure standard, $\sigma_{\epsilon e}^2$, $e \in \{1,2\}$; insiders choose an exchange on which to list their firms; liquidity traders choose an allocation of their demands, $\{g_{mn}\}_{m \in M}$ such that $\sum_{m \in M} g_{mn} = 1$, for $n \in N$; insiders choose the level of their demands conditional on the public signal and their private observation of firm value, $x_m(v_m, \theta_{em}) = \beta_m(v_m - E[v_m|\theta_{em}])$, where $E[v_m|\theta_{em}] = \left(\theta_{em}\sigma_v^2 + \bar{v}\sigma_{\epsilon e}^2\right) / \left(\sigma_v^2 + \sigma_{\epsilon e}^2\right)$; and market makers, who receive orders for the sum of insider demands and liquidity traders' allocated demands, $y_m = x_m + \sum_{n \in N} g_{mn} u_n$, choose prices conditional on the total order flow, $p_m(y_m, \theta_{em}) = E[v_m|\theta_{em}] + \lambda_m y_m$. Since we assume linearity in prices and insider demands, insiders' and market makers' strategy choices reduce to parameters λ_m and β_m, respectively, for $m \in M$. Normality of random variables assures that the posterior variance of end-of-period firm value, $\sigma_{v_m|\theta_{em}}^2$, is constant for any realization of the public signal for the firm. A time line is provided below:[7]

[7] While there is only one trading round, our analysis also would apply if the last four steps of the time line above were iterated. In this modest elaboration of the model, each firm's value is perturbed at the beginning of every trading round by a shock that is privately observed by the firm's insider. Thus, insiders are endowed before every trading round with short-lived private information. Disclosure rules govern the size of the information asymmetry that insiders exploit in each iteration.

↑	↑	↑	↑	↑	↑
Exchanges choose their disclosure standards.	Insiders decide where to list their firm's stock.	Public signals are revealed.	Insiders choose their demands; liquidity shocks are realized; and, liquidity traders allocate demands to markets and to firms.	Market makers set prices based on order flow.	Liquidation values are realized.

We assume listing decisions are observable to liquidity traders and market makers before the former allocate their demands, and allocation decisions are not observable to market makers or insiders before trading takes place. These assumptions are natural in that trading decisions do not generally involve the level of commitment apparent in listing decisions. The results are qualitatively similar when sequential play is assumed. We further assume trading in each stock is simultaneous so order flow for one stock cannot be observed by other market participants. Accordingly, market makers draw no inferences about the informed component of the order flow in which they make a market beyond those drawn from common knowledge.[8]

Our characterization of liquidity traders as quasi-rational agents sensitive to trading costs but otherwise compelled to meet exogenously generated demands is similar to other models in which liquidity traders allocate exogenous demands over time rather than exchanges and securities (e.g., Admati and Pfleiderer, 1988, and Bushman, et al., 1997). At a qualitative level, the crucial aspect is whether there exist classes of traders motivated to trade for non-strategic purposes and who derive sufficient benefits from meeting their objectives to bear costs implied by the presence of informationally-advantaged insiders.

[8] If a liquidity trader can observe order flows for stocks before submitting his order, then he would similarly make inferences about the informed component of order flow in individual stocks and potentially alter his allocation of trades across stocks.

The modeling choice to place listing decisions in the hands of insiders represents a worst-case scenario for unregulated exchanges. Later, we allow insiders to share reductions in firm value (attributable to listing fees, and compliance and listing costs) that accompany listing on the high disclosure exchange.

3. Benchmark Case

3.1 Liquidity Traders' Allocation Decisions

The expected loss of liquidity trader n aggregated over the M securities in which he may have a position is

$$\begin{aligned}
&-\sum_{m\in M} E_{u_1,\ldots,u_N} E_{v_m|\theta_{em}} \left[g_{mn}u_n\left(v_m - p_m(y_m,\theta_{em})\right)\right] \\
&= -\sum_{m\in M} E_{u_1,\ldots,u_N} E_{v_m|\theta_{em}} \left[g_{mn}u_n\left(v_m - \left(v_{\theta_m} + \lambda_m\left(x_m(v_m,\theta_{em}) + \sum_{n\in N} g_{mn}u_n\right)\right)\right)\right] \\
&= \sum_{m\in M} \lambda_m g_{mn}^2 E_{u_n}[u_n^2] \qquad \text{(since } u_n \text{ is independent of } x_m(v_m,\theta_{em}) \text{ and } u_j \text{ for } n\neq j) \\
&= \sigma_u^2 \sum_{m\in M} \lambda_m g_{mn}^2. \qquad (1)
\end{aligned}$$

Given conjectured price adjustments $\hat{\lambda}_m$, $m \in M$, the liquidity trader's problem is

$$\min_{\{g_{mn}\}_{m\in M}} \sum_{m\in M} \hat{\lambda}_m \sigma_u^2 g_{mn}^2 \qquad (2)$$

subject to

$$\sum_{m\in M} g_{mn} = 1. \qquad (3)$$

In equilibrium, the conjectured price adjustments must be consistent with each market maker's actual adjustment based on the order flow and his conjectures of liquidity traders' allocations, $\hat{g}_{mn}$, $n \in N$:

$$\hat{\lambda}_m = \lambda_m \equiv \frac{\sigma_{v_m|\theta_{em}}}{2\sigma_u\sqrt{\sum_{n\in N}\hat{g}_{mn}^2}}. \qquad (4)$$

The right-hand side of (4) is a generalization of Kyle's (1985) result for a single market in which there is one traded asset, one insider and one liquidity trader. As well, the market maker's conjectures must be consistent with the solutions, denoted g^*_{mn}, to the above problem for each liquidity trader:

$$\hat{g}_{mn} = g^*_{mn}, \quad \text{for } m \in M \text{ and } n \in N. \tag{5}$$

The following partial characterization of equilibrium allocations illustrates an effect we term "flocking."

Proposition 1: *An equilibrium allocation of liquidity trading over securities is symmetric, i.e., for $m \in M$ $g_{mi} = g_{mj}$ for $i, j \in \{1, \ldots, N\}$.* [9]

Given some liquidity in a security, all liquidity traders find it worthwhile to realize some of their demand in that security. This effect is similar to the temporal concentration of liquidity traders in section 1 of Admati and Pfleiderer (1988). In section 4 of their paper, where they relax the all-or-nothing restriction, Admati and Pfleiderer find that allocations, while symmetric, are made to more than one period. The uniqueness of equilibrium allocations in their dynamic framework is due to the inferences traders draw from order flows of prior periods. Since trade is simultaneous in our analysis, liquidity traders are indifferent over symmetric allocations of liquidity across firms that provide the same level of disclosure.

We next consider the allocation of liquidity given fixed numbers of firms, M_1 and M_2, have chosen to list on exchanges 1 and 2, respectively. To facilitate the analysis, we assume a lower bound, d, on the percentage of each liquidity trader's demands allocated to every firm.[10]

$$g_{mn} \geq d \quad \text{for } m \in M, \tag{6}$$

where $0 < d < 1/M$.

[9] See appendix for a proof.

[10] Such a bound is consistent with index mutual funds, which distribute liquidity demands of small traders across large portfolios thereby providing some liquidity in each indexed security. Existence of some non-discretionary liquidity is present in many models of quasi-rational liquidity traders including Admati and Pfleiderer (1988), Bushman et al. (1997), and Chowdhry and Nanda (1991).

It follows from the first-order conditions that

$$g^*_{mn} = \frac{\mu_n + \gamma_{mn}}{2\sigma_u^2 \hat{\lambda}_m}, \tag{7}$$

where μ_n and γ_{mn} are the Lagrange multipliers corresponding to (3) and (6), respectively. Substituting (7) into (3) yields

$$1 = \sum_{m \in M} \frac{\mu_n + \gamma_{mn}}{2\sigma_u^2 \hat{\lambda}_m},$$

which holds for every trader $n \in N$. This implies $\mu_n = \mu$ and $\gamma_{mn} = \gamma_m$ are constant over n. Exploiting these observations, and substituting (7) into (4) yields

$$\mu + \gamma_m = \frac{\sigma_u \sigma_{v|e}}{\sqrt{N}} \quad \text{for } m \in M,$$

where we have simplified our notation such that $\sigma_{v|e}$ replaces $\sigma_{v_m|\theta_{em}}$. The above implies γ_m is constant by exchange, e. Also $\gamma_m < \gamma_{m'}$ for $m \in M_1$ and $m' \in M_2$ since $\sigma_{v|1} < \sigma_{v|2}$. Furthermore, (6) cannot be binding for all M because $d < {}^1\!/_M$ by assumption. Thus, $\gamma_m = 0$ for $m \in M_1$; and, $g_{mn} = d$ for $m \in M_2$ and $n \in N$. Combining these observations with (3) and (7) leads to the following characterization of equilibrium allocations:

$$g_{mn} = \begin{cases} \frac{(1-dM_2)}{\lambda_m \Lambda(M_1)}, & \text{for } m \in M_1, \\ d, & \text{for } m \in M_2, \end{cases} \tag{8}$$

where $\Lambda(M_e) = \sum_{m \in M_e} {}^1\!/_{\lambda_m}$. The next proposition is immediate:

Proposition 2: *Given firm listings are fixed by exchange with at least one firm listing on each exchange, in equilibrium all liquidity beyond the lower bound for each firm is allocated to the high disclosure exchange.*

Thus, liquidity traders allocate as much of their demands as possible to stocks for which the informational advantage of insiders is least. This migration to the high disclosure exchange is unaffected by the number of firms listed on that exchange since equilibrium trading intensity for each insider is proportional to the liquidity allocated to the corresponding firm.

3.2 Insiders' listing decisions

Although liquidity traders are indifferent over symmetric allocations to firms meeting the same disclosure level, we find it convenient in addressing insiders' listing decisions to assume they choose an equal allocation. An equal allocation would also seem to be focal.

Generalizing from Kyle (1985) once again, expected insider profits for firm m are

$$\tfrac{1}{2}\sigma_u \sigma_{v|e} \sqrt{\sum_{n=1}^{N} g_{mn}^2}, \quad e \in \{1, 2\}. \tag{9}$$

Given an equal allocation, (8) and (9) imply the expected profit of an insider listing her firm on exchange 1 is

$$\tfrac{1}{2}\sigma_u \sigma_{v|1} \left(\frac{1 - df_2 M}{f_1 M} \right) \sqrt{N},$$

where f_e denotes the fraction of firms listing on exchange e. The expected profit of an insider listing her firm on exchange 2 is

$$\tfrac{1}{2}\sigma_u \sigma_{v|2} d \sqrt{N}.$$

Equating expected profits and solving for f_1 leads to the following result:

Proposition 3: *Given insiders can choose the exchange on which to list their firms, and liquidity traders can choose exchanges and firms over which to allocate their demands,*

(i) if $d \geq \sigma_{v|1}/(\sigma_{v|2} M)$, *then*

$$f_1 = \frac{\sigma_{v|1}(1 - dM)}{(\sigma_{v|2} - \sigma_{v|1}) dM},$$

(ii) otherwise, all firms list on the exchange with the highest level of disclosure, $f_1 = 1$.

Given one exchange and two disclosure levels, insiders are caught in a competition for liquidity that leaves all insiders worse off. While high disclosure reduces an insider's information advantage, it also attracts more liquidity, and the liquidity effect dominates.[11]

[11] If $d \leq \sigma_{v|1}/(\sigma_{v|2} M)$ then f_1 achieves its upper bound of 1. Otherwise, since $d < 1/M$ implies $1 - dM > 0$ and $\sigma_{v|2} - \sigma_{v|1} > 0$, $0 < f_1 < 1$.

The concentration of firm listings on the exchange where insiders enjoy less of an information advantage is similar to Bushman et al.'s (1997) result that insider demands are concentrated in the period after a public signal has been released. As in our model, their following effect, analogous to our liquidity effect, dominates the informational effect leading to this behavior.[12]

Each choice of d characterizes an equilibrium in which all mobile liquidity is allocated to the high disclosure exchange.[13] As $d \to 0$, these equilibria approach equilibria in a game for which all liquidity is mobile. It is easy to check that an equilibrium in the limiting case of no trapped liquidity has all firms listing on the high disclosure exchange.

Proposition 4: *In the limiting case as $d \to 0$, an equilibrium exists in which all firms list on the high disclosure exchange, and all liquidity is allocated to that exchange.*

3.3 Equilibrium disclosure standards

Stepping back to consider the decisions of exchanges in setting disclosure requirements, we assume exchanges are strategic players that seek to maximize expected volume, which we define as the aggregate fraction of liquidity traders' shocks allocated to firms listed on exchange e, $\sum_{m \in M_e} \sum_{n \in N} g_{mn}$. We leave unspecified how exchange profits are related to volume; however, if the exchange (or its members) collects fees per unit traded, then higher volume means higher revenues. Moreover, because traders' preferences are strict, the high disclosure exchange is able to collect a higher fee per unit traded than the low

[12] The behavior is less robust in their model due to the market maker's ability to draw an inference about the liquidity component of the order flow in the second period, thereby becoming better able to detect the insider-driven component. Hence, the following effect must overcome both the direct reduction of informational advantage from release of the public signal, and the indirect reduction due to the partial loss of disguise.

[13] When d is sufficiently low, insiders find the greater disguise for their trades available on the high disclosure exchange (due to the migration of mobile liquidity there) exceeds their forgone information advantage. When d is sufficiently high, a positive fraction of firms list on the low disclosure exchange. As one lowers the precision of the signals on the low disclosure exchange, ceteris paribus, two things happen: (i) given a sufficiently high level of d, the fraction of firms listing on the low disclosure exchange increases; and (ii) the threshold level of d for this case to apply decreases. Expected volume on the low disclosure exchange increases only to the extent more listings bring more liquidity there. Fraction $1 - d$ is allocated to the high disclosure exchange no matter which case obtains.

disclosure exchange without altering our results.[14] If both exchanges choose the same standard, we further assume they attract equal allocations of liquidity and firm listings. The next proposition provides a sufficient condition for both exchanges to set the highest feasible disclosure standard:

Proposition 5: *If*

$$2dM - 1 < \frac{\underline{\sigma}_v}{\sigma_v}, \tag{10}$$

where $\underline{\sigma}_v^2$ is the variance of firm value conditioned on the public signal from the highest feasible disclosure standard and σ_v^2 is the ex ante variance of firm value, then both exchanges choose the highest feasible disclosure standard in the unique equilibrium.[15]

In particular, if the lower bound on liquidity allocations by firm is small, i.e., $dM < 1/2$, then both exchanges "race for the top" by selecting the highest feasible disclosure standard no matter how precise.

One response to an exchange that sets a standard below the highest feasible level is to set a slightly higher standard. This will attract all mobile liquidity. From the insider's perspective, the liquidity effect from listing on the high disclosure exchange will dominate the information effect for a sufficiently small difference in standards, so all firms list on the high disclosure exchange. Given an exchange chooses the highest feasible standard, the other exchange may either match that standard and split the trading activity, or choose the lowest standard, which we allow to be completely uninformative. The desirability of the latter choice increases in the amount of liquidity accompanying firms listing on the lowest disclosure exchange. Since there is an upper bound on the precision of public signals under the highest feasible standard, there is a low enough level of trapped liquidity to ensure that the lowest standard would not attract sufficient listings to make that choice worthwhile, namely (10).

[14] We believe such "fees" are a component of the bid-ask spread. Alternatively, one could assume exchange profits derive primarily from fees collected from firms that list on the exchange. Accordingly, we also consider the allocation of firms across exchanges. In fact, listing fees are modest: The original listing fee is less than $800,000 for a company with 200,000,000 or fewer shares outstanding on the NYSE, AMEX, or Nasdaq. The annual maintenance fee never exceeds $500,000 for any number of shares on any of these exchanges (Aggarwal and Angel, 1996).

[15] See appendix for a proof.

4. Explaining Low Disclosure Standards

4.1 Risk Aversion

In the section 3, we saw that the flocking effect cannot induce risk-neutral liquidity traders to allocate demands to low disclosure exchanges, insiders seeking liquidity list on high disclosure exchanges, and exchanges resolve their competition by setting disclosure standards as high as possible. Here we consider whether risk-averse liquidity traders who benefit from diversifying their portfolios by allocating some demands to firms listed on the low disclosure exchange can rationalize insider decisions to list on the low disclosure exchange. Specifically, we assume that liquidity traders' preferences are given by the utility function $U(w) = -\exp(-rw)$, $r > 0$, where w is end-of-period wealth. Both insiders and market makers are risk neutral.

Liquidity trader n's problem in choosing an allocation can be expressed as follows:[16]

$$\min_{\{g_{mn}, m \in M\}} E\left(U\left(\sum_{m \in M}\left(g_{mn} u_n\left(p(y, \theta_{em})\right) - v_m\right)\right)\right) \tag{11}$$

subject to

$$\sum_{m \in M} g_{mn} = 1.$$

Using the well-known equivalence between $E(U(w))$ and $E(w) - {}^{r}\!/_{2}\mathrm{Var}(w)$ for normal random variables, substituting for price, and applying expectation and variance operators result in the restatement of (11) shown below:[17]

$$\max_{\{g_{mn}, m \in M\}} u_n^2 \sum_{m \in M} g_{mn}^2 \left(-\lambda_m - \frac{r}{2}\left(\left(1 - \lambda_m \beta_m\right)^2 \sigma^2_{v_m|\theta_{em}} + \lambda_m^2 \sigma_u^2 \sum_{k \in N} g_{mk}^2\right)\right) \tag{12}$$

[16] With risk aversion, we have no need of the lower bound d on per firm allocations of liquidity that we used earlier.

[17] A subtle change in timing (reflected by u_n^2 in place of σ_u^2 below) is that we now assume liquidity traders observe the realization of their individual demand shock before choosing their allocation. This assumption preserves normality and hence the transformation to a quadratic objective function, but is otherwise innocuous.

Let μ_n be the Lagrange multiplier on the constraint. Suppressing a factor of u_n^2, the derivative of the Lagrangian to this problem with respect to g_{mn} is:

$$2g_{mn}\left[-\lambda_m - {}^1\!/\!_2 r\left(\left(1-\lambda_m\beta_m\right)^2\sigma^2_{v_m|\theta_{em}} + \lambda_m^2\sigma_u^2\sum_{\substack{k\in N\\ k\neq n}} g_{mk}^2\right)\right] + \mu_n.$$

As in before, we can write

$$\lambda_m = \frac{1}{2\beta_m} = \frac{\sigma_{v_m|\theta_{em}}}{2\sigma_u\sqrt{\sum_{k\in N} g_{mk}^2}}. \tag{13}$$

Imposing symmetry (i.e., $g_{mn} = g_m$ for all $n \in N$) and substituting (13) into the Lagrangian yields:

$$-\frac{\sigma_{v_m|\theta_{em}}}{\sigma_u\sqrt{N}} - \left(\frac{2N-1}{4N}\right) r\sigma^2_{v_m|\theta_{em}} g_m + \mu.$$

The first order condition, that the quantity above is zero for all $m \in M$, implies

$$g_m = \frac{1}{r\sigma^2_{v_m|\theta_{em}}}\,\frac{4N}{2N-1}\left(\mu - \frac{\sigma_{v_m|\theta_{em}}}{\sigma_u\sqrt{N}}\right).$$

If we assume as before there exist two exchanges and $\sigma_{v_m|\theta_{em}} = \sigma_{v|1}$ for the M_1 firms listing on the high disclosure exchange and $\sigma_{v_m|\theta_{em}} = \sigma_{v|2}$ for the M_2 firms listing on the low disclosure exchange, then we also have $g_m = g_e$ for $m \in M_e$ and $g_1M_1 + g_2M_2 = 1$. This implies

$$\begin{aligned}\mu =& \frac{\frac{r(2N-1)}{4N} + \frac{1}{\sigma_u\sqrt{N}}\left(\frac{M_1}{\sigma_{v|1}} + \frac{M_2}{\sigma_{v|2}}\right)}{\frac{M_1}{\sigma^2_{v|1}} + \frac{M_2}{\sigma^2_{v|2}}}\\ =& \frac{r(2N-1)}{4N}\,\frac{\sigma^2_{v|1}\sigma^2_{v|2}}{M_1\sigma^2_{v|2} + M_2\sigma^2_{v|1}} + \frac{\sigma_{v|1}\sigma_{v|2}}{\sigma_u\sqrt{N}}\,\frac{M_1\sigma_{v|2} + M_2\sigma_{v|1}}{M_1\sigma^2_{v|2} + M_2\sigma^2_{v|1}}.\end{aligned}$$

Substituting for μ in the expression for g_m above gives:

$$g_m = \begin{cases} \dfrac{\sigma^2_{v|2} + \frac{4N}{2N-1}\,\frac{(\sigma_{v|2}-\sigma_{v|1})M_2}{r\sigma_u\sqrt{N}}}{M_1\sigma^2_{v|2} + M_2\sigma^2_{v|1}} & \text{for } m \in M_1\\[2ex] \dfrac{\sigma^2_{v|1} + \frac{4N}{2N-1}\,\frac{(\sigma_{v|1}-\sigma_{v|2})M_1}{r\sigma_u\sqrt{N}}}{M_1\sigma^2_{v|2} + M_2\sigma^2_{v|1}} & \text{for } m \in M_2 \end{cases}$$

Let $P_e(M_1, M_2)$ denote the profit earned by an insider whose firm is listed on exchange e when there are M_1 and M_2 firms listed on exchanges 1 and 2, respectively. Observe

$$\begin{aligned} P_e(M_1, M_2) &= {}^1\!/_2 \sigma_u \sigma_{v|e} \sqrt{\sum_{n \in N} g_{mn}^2} \\ &= {}^1\!/_2 \sigma_u \sigma_{v|e} \sqrt{N} g_e. \end{aligned}$$

For an equilibrium to exist in which M_1 firms list on exchange 1 and M_2 firms list on exchange 2, no firm must have an incentive to switch its listing decision. This implies that the profits to firms listed on each exchange must be equal. However, we find

Proposition 6: *Given $\sigma_{v|1} < \sigma_{v|2}$, each insider prefers to list her firm on the high disclosure exchange for any choice of M_1 and M_2.*[18]

This implies all firms list on the high disclosure exchange. Although liquidity traders will allocate some of their demands to firms listing on the low disclosure exchange, that allocation is so small that insiders prefer to sacrifice their informational advantage for the greater depth that remains on the high disclosure exchange. For liquidity traders there are two forces at work: a desire to diversify and a desire to avoid higher trading costs. By listing on the low-disclosure exchange, a firm attracts some liquidity due to the former. However, by listing on the high-disclosure exchange, a firm attracts liquidity for both reasons. As a consequence, the liquidity effect dominates the loss of information advantage in the firm's listing decision.

4.2 Trapped Liquidity

Next, we consider whether institutional impediments to cross-border securities trading might sustain insiders listing on low disclosure exchange, and, if so whether equilibrium choices by exchanges include setting low disclosure standards. While the trend is toward greater mobility of liquidity due to innovations in communications, data processing, security design (e.g., ADRs), and deregulation of securities markets, frictions and regulatory restrictions continue to inhibit the transnational flows of liquidity. In the US, there are

[18] See appendix for proof.

tax disincentives to investing in foreign assets including prohibitions on deducting losses on foreign holdings from capital gains on other securities, and requirements to pay taxes on undistributed foreign source income. In addition, the SEC seeks to apply US securities law extraterritorially. For example, if a US person is involved in a transaction or even if a transaction incidentally affects US markets, the SEC may assert that US securities laws and attendant disclosure requirements apply. For this reason, certain offshore funds refuse investment from US persons, thereby restricting the allocation of their liquidity demands (Sesit, 1996). These practices trap US investors' liquidity on US exchanges, irrespective of the quality of foreign jurisdictions' disclosure rules.[19]

We model these institutions by letting $D_e \in (0,1)$, $e \in \{1,2\}$, denote the fractions of liquidity trapped by exchange for each liquidity trader associated with that exchange. The problem for trader $n \in N_e$, is to minimize (2) subject to (3) and:

$$\sum_{m \in M_e} g_{mn} \geq D_e. \tag{14}$$

For this problem, we have the following characterization of liquidity traders' equilibrium strategies:

Proposition 7: *Given $\sigma_{v|1} < \sigma_{v|2}$, $D_e \in (0,1)$ for $e \in \{1,2\}$, and at least one firm listing on each exchange, in equilibrium:*

(i) all mobile liquidity from the low disclosure exchange is allocated to the high disclosure exchange;

(ii) if

$$\frac{1}{1 + \frac{\sigma_{v|1}}{\sigma_{v|2}} \sqrt{\frac{N_1(1-D_1)^2 + N_2 D_2^2}{N_1 D_1^2 + N_2(1-D_2)^2}}} < D_1, \tag{15}$$

[19] As another example, Canadian tax law provides for "foreign property rules" that require foreign asset holdings in registered retirement plans, an IRA-like vehicle, to be less than 20% of plan capital for pre-tax dollars to accumulate in these plans tax free. Thus, there is a significant tax cost for Canadian investors to allocate more than 20% of wealth, and hence liquidity demands, to foreign stocks. This example also highlights the role innovation in security design can have in facilitating liquidity mobility. In Canada, derivative securities have been constructed to circumvent the foreign property rules. These derivatives offer high exposure to foreign markets for little capital as defined by the rules (MacIntosh, 1995).

and,

$$\frac{1}{1+\frac{\sigma_{v|2}}{\sigma_{v|1}}\sqrt{\frac{N_1 D_1^2+N_2(1-D_2)^2}{N_1(1-D_1)^2+N_2 D_2^2}}} < D_2, \tag{16}$$

then all mobile liquidity from the high disclosure exchange is allocated to the low disclosure exchange; and,

(iii) if the above inequalities do not hold, then the fraction of the liquidity of traders associated with exchange 1 that is allocated to exchange 1, X, is the unique solution in $(D_1, 1)$ to

$$\left(\frac{\sigma_{v|1}}{\sigma_{v|2}}\right)^2 \left(N_1 + N_2\left(\frac{D_2}{1-X}\right)^2\right) = N_1 + N_2\left(\frac{1-D_2}{X}\right)^2. \tag{17}$$

See the appendix for a proof. There are two types of equilibria: in one, the constraints for liquidity trapped on both exchanges are binding; in the other, only the constraints for liquidity trapped on the low disclosure exchange are binding. Both classes of equilibria are generic. It is straightforward to show from part (ii) of the proposition that $D_1 + D_2 < 1$ implies (14) is not binding for the high disclosure exchange. Thus when trapped liquidity is small, all mobile liquidity from the low disclosure exchange and most of the liquidity from the high disclosure exchange is allocated to the high disclosure exchange.

The flocking effect causes traders to want to trade in the same securities and hence on the same exchange. The information effect causes traders to want to trade on the high disclosure exchange. Constraints for liquidity trapped on the low disclosure exchange always prevent traders on that exchange from optimally exploiting the lower information rents to insiders on the high disclosure exchange. Constraints for liquidity trapped on the high disclosure exchange may prevent traders on the high disclosure exchange from optimally flocking with the liquidity trapped on the low disclosure exchange.

The surprising part of this proposition is that it is possible for the constraint for liquidity trapped on the high disclosure exchange to be binding. It is easy to check that the fraction of liquidity attracted from the high disclosure exchange to the low disclosure exchange decreases in the precision of the public signals for the high disclosure exchange, and increases in the percentage of liquidity trapped on the low disclosure exchange. The key insight is that with a small difference in disclosure standards and a lot of liquidity trapped on both exchanges, the effect of liquidity concentrated on the low disclosure exchange more than offsets insiders' information advantage, so liquidity traders from the high disclosure exchange voluntarily trade on the low disclosure exchange. Of course, better yet for liquidity traders would be for them to concentrate all liquidity on the high disclosure exchange, but liquidity trapped on the low disclosure exchange prevents them from doing so.

With little liquidity trapped on either exchange, we have the intuitive result that all mobile liquidity from the low disclosure exchange seeks the reduction of insiders' information advantage. The flocking effect is also present, and continues to cause some liquidity from the high disclosure exchange to be allocated to the low disclosure exchange.

As in section 3, we assume each trader allocates the same fraction of his liquidity to every firm meeting the same disclosure standard. The equilibrium allocation is

$$g_{mn} = \begin{cases} \frac{Z}{f_1 M}, & \text{if } m \in M_1 \text{ and } n \in N_1; \\ \frac{1-Z}{1-f_1 M}, & \text{if } m \in M_2 \text{ and } n \in N_1; \\ \frac{D_2}{1-f_1 M}, & \text{if } m \in M_2 \text{ and } n \in N_2; \\ \frac{1-D_2}{f_1 M}, & \text{if } m \in M_1 \text{ and } n \in N_2; \end{cases}$$

where, $f_1 M = M_1$, $Z = \max\{X, D_1\}$, and X is defined by proposition 7. It follows that expected profits for the marginal insider are

$$1/2 \frac{\sigma_u \sigma_{v|1}}{f_1 M} \sqrt{N_1 Z^2 + N_2 (1 - D_2)^2}, \quad \text{and} \tag{18}$$

$$1/2 \frac{\sigma_u \sigma_{v|2}}{(1 - f_1) M} \sqrt{N_1 (1 - Z)^2 + N_2 D_2^2} \tag{19}$$

from listing on the low and high disclosure exchanges, respectively. Equating (18) and (19) shows how firms divide themselves between exchanges

Proposition 8: *Given some liquidity is trapped on the low disclosure exchange, in equilibrium*

$$f_1 = \frac{\sigma_{v|1}\sqrt{N_1 Z^2 + N_2(1-D_2)^2}}{\sigma_{v|1}\sqrt{N_1 Z^2 + N_2(1-D_2)^2} + \sigma_{v|2}\sqrt{N_1(1-Z)^2 + N_2 D_2^2}}.$$

If we allow exchanges to be strategic players that seek to maximize volume as in section 3.3 then the unique equilibrium disclosure choice for each exchange is the highest feasible disclosure standard.

Proposition 9: *Both exchanges choose the highest feasible disclosure standard in equilibrium.*[20]

When disclosure standards differ, it is evident from the proof of Proposition 7 that (14) is binding only for the low disclosure exchange. This implies more liquidity is allocated to the high disclosure exchange. Thus, the best response of one exchange to a standard chosen by the other is to set as high a standard as feasible, again implying a race for the top.

4.3 Listing Costs

So far, we looked at factors that relate directly to liquidity allocations, but only indirectly to listing decisions. We now consider how costs associated with listing on a high disclosure exchange affect those decisions and, hence, the competition between exchanges in setting disclosure standards. By listing costs we mean the listing fees an exchange charges; the direct cost of providing the mandated level of disclosure, including internal accounting activity, and audit and publication costs; and, the indirect proprietary costs associated with disclosures made to participants in the financial market for the firm's stock that also reveal private information to rival companies in the product market.[21]

[20] See appendix for a proof.

[21] For example, among the respondents to a Discussion Memorandum issued by the FASB pursuant to its issuance of Statement of Financial Accounting Standards 14 on segment reporting were opponents who contended that compliance with those rules would injure their competitive position. Feltham et al. (1992), Gigler et al. (1994), and Hayes and Lundholm (1996) offer support for such concerns. The segment reporting context is especially appropriate in that, at an abstract level, the segment versus aggregate reporting alternatives correspond to an ordering through statistical sufficiency. There may also be a more subtle cost associated with greater precision of public signals used in manager compensation arrangements. Greater precision may imply less reliance by market makers on non-contractible signals about manager efforts thereby reducing the efficiency of such arrangements (Baiman and Verrecchia, 1996).

Listing costs are borne by the firm's shareholders. The higher the listing costs, the lower is the firm's stock price, ceteris paribus. It is natural to assume listing costs are increasing in the level of disclosure.[22] Specifically, let v_m denote the value of the firm net of listing costs. We assume the expected value of the firm prior to the trading round and after the listing decision, $\bar{v}_m$, correctly impounds the listing costs, i.e., $v_m \sim NID(\bar{v}_m, \sigma_m^2)$. Suppose the insider has no endowed stake in the firm, i.e., at the time the listing decision is made, the insider is neither long nor short the firm's stock. Then choosing to list on either the high or low disclosure exchange has no direct effect on the insider's payoff. In this setup, listing costs are an externality imposed on stockholders *before* the trading round, implying that the analysis proceeds exactly as before.

Suppose now that each insider has an endowed stake in the firm, α, implying insider's listing decisions are sensitive to the listing costs. Analogous to (9), the profit to an insider from listing on the high disclosure exchange is

$$^1\!/_2\sigma_u\sigma_{v|1}\left(\frac{1-df_2M}{f_1M}\right)\sqrt{N}-\alpha C(\sigma_{v|1}),$$

where $C(\sigma_{v|e})$ are costs of listing on exchange e. The profit from listing on the low disclosure exchange is

$$^1\!/_2\sigma_u\sigma_{v|2}d\sqrt{N}-\alpha C(\sigma_{v|2}).$$

For an equilibrium allocation of firms to exchanges, the marginal insider must be indifferent to listing on either the high or low disclosure exchange. Equating the last two expressions yields the following generalization of Proposition 3:

Proposition 10: *Given insiders can choose what exchange on which to list their firms, and liquidity traders can choose exchanges and firms over which to allocate their demands,*

(i) if $d \geq \sigma_{v|1}/(\sigma_{v|2}M) + J/\sigma_{v|2}$*, then*

$$f_1 = \frac{\sigma_{v|1}(1-dM)}{\big(J+(\sigma_{v|2}-\sigma_{v|1})d\big)\,M}, \tag{20}$$

[22] If listing costs at the high disclosure exchange are less than on the low disclosure exchange, then disclosure costs reinforce the the flocking effect documented above and a race for the top result identical to the one derived in section 3 obviously follows.

where $J = \frac{2\alpha}{\sigma_u \sqrt{N}} \left(C(\sigma_{v|1}) - C(\sigma_{v|2}) \right)$,

(ii) otherwise, all firms list on the exchange with the highest level of disclosure, $f_1 = 1$.

Relative to the benchmark case, higher listing costs for higher levels of disclosure lead to fewer firms listing on the high disclosure exchange. Two clientele effects are apparent. If firms differ in the endowed ownership stake of the insider, then firms sort themselves between exchanges so that those with the highest insider ownership, ceteris paribus, list on the low disclosure exchange. If firms vary in the increase in disclosure costs associated with listing on the high disclosure exchange, then firms sort themselves between exchanges so that those with facing the greatest increase in disclosure costs, ceteris paribus, list on the low disclosure exchange. In either case, condition (20) then applies to the firm at the margin. Nevertheless, listing costs do not preclude a race for the top when liquidity is sufficiently mobile, as the following analog to Proposition 5 shows:

Proposition 11: *If*

$$2dM - 1 < \frac{\underline{\sigma}_v}{\sigma_v + {}^{J}\!/_{d}}, \tag{21}$$

where $\underline{\sigma}_v^2$ *is the variance of firm value conditioned on the public signal from the highest feasible disclosure standard,* σ_v^2 *is the ex ante variance of firm value, and* $J = \frac{2\alpha}{\sigma_u \sqrt{N}} \left(C(\underline{\sigma}_v) - C(\sigma_v) \right)$, *then both exchanges choose the highest feasible disclosure standard in the unique equilibrium.*[23]

As d becomes small, the left-hand side of (21) becomes negative, while the right-hand side is always positive. So in the limit, insiders choose to list all firms on the high disclosure exchange regardless of the listing cost and for any ownership stake.

[23] See appendix for a proof.

5. Extensions

5.1 Cross-listing

We now assume cross-listing is feasible, provided the firm meets or exceeds the disclosure standards for each exchange. Thus, cross-listing to a higher disclosure exchange requires greater disclosure, whereas cross-listing to a lower disclosure exchange involves no additional disclosure. For simplicity, we present a case in which all liquidity of traders $n \in N_e$, $e \in \{1, 2\}$, must be allocated to stocks listed on exchange e and each firm listed on exchange e must receive at least fraction d of the demands of traders $n \in N_e$. Let f_e again be the fraction of firms listed on exchange e alone. Let c be the fraction of the firms that are cross-listed. Then $f_1 \geq 0, f_2 \geq 0, c \geq 0$, and $f_1 + f_2 + c = 1$. Assume the insider associated with each firm can trade on every exchange where the stock is listed, but each liquidity trader may trade only on the exchange to which he is exogenously associated. Plainly, $f_1 = 0$ since a firm listed in market 1 can increase the number liquidity traders in its stock without making additional disclosures, and hence increase the insider's profit by cross-listing.

The expected profit earned by an insider on the low disclosure exchange is complicated because liquidity traders recognize that some firms trading there are subject to a higher disclosure standard. Hence, the informational advantage of the insiders associated with those firms is correspondingly reduced, implying liquidity traders allocate more trading to the high disclosure firms. From Proposition 2, the weights applied to cM cross-listed firms by liquidity traders associated with exchange 2 are each

$$\frac{1 - df_2 M}{cM},$$

while the weights applied to the $f_2 M$ firms listed only on the low disclosure exchange are each d. From (9), the expected profit of an insider who lists only on exchange 2 is

$$\sfrac{1}{2}\sigma_u \sigma_{v|2} d\sqrt{N_2},$$

while the expected profit of an insider who cross-lists is

$$\frac{1}{2}\sigma_u \sigma_{v|1} \frac{\sqrt{N_1}}{cM} + \frac{1}{2}\sigma_u \sigma_{v|1} \sqrt{N_2} \left(\frac{1 - df_2 M}{cM} \right).$$

The first term in this sum is the profit earned on the high disclosure exchange, the second is the profit earned on low disclosure exchange.[24] The equilibrium allocation of firms to exchanges equates the profit of an insider listed only on the low disclosure exchange with the profit of an insider who cross-lists. Simplifying this equality yields the following:

Proposition 12: *Given insiders can choose to list their firms on either one exchange or cross-list on both exchanges, and each liquidity trader is constrained to buy or sell only the stocks listed on the exchange to which he is exogenously assigned, the allocation of firms between markets is decided according to*

$$c = \frac{\sigma_{v|1}}{\sigma_{v|2} - \sigma_{v|1}\sqrt{N_2}} \left[\frac{\sqrt{N_2} + (1 - dM)\sqrt{N_1}}{dM} \right]. \tag{22}$$

When this quantity lies between zero and unity, it is the fraction of firms that cross-list. When this quantity exceeds unity, all firms cross-list. When this quantity is less than zero, all firms list on the low disclosure exchange only.

The quantity c depends on the number of liquidity traders constrained to trade on each of the two exchanges, N_1 and N_2; the posterior precisions of firm values following the release of signals under the two disclosure standards, $\sigma_{v|1}$ and $\sigma_{v|2}$; and the minimum liquidity a trader must allocate to a firm, d. When (22) implies $c < 0$, the non-negativity constraint on c binds. This happens as the number of liquidity traders on the low disclosure exchange grows large, or the posterior variance of firm value on the high disclosure exchange becomes very small. In such cases, all firms prefer to list solely on the low disclosure exchange because the opportunity to profit from the liquidity in the high disclosure exchange is more than offset by the concomitant loss of informational advantage on the low disclosure exchange. On the other hand, it is possible for (22) to imply that $c > 1$. In this case, the

[24] This statement of profits assumes markets are segmented. If markets are integrated, then the expected profits of an insider who cross-lists are lower, but the comparative statics that follow are similar.

constraint $c \leq 1$ binds, so all insiders prefer to list their firm on the high disclosure exchange and cross-list on the low disclosure exchange. This happens when the number of liquidity traders trapped on the low disclosure exchange is small, and the minimum liquidity each trader at the low disclosure exchange must allocate to a low disclosure stock, d, is small.

For intermediate posterior variance values, similar numbers of liquidity traders at each exchange, and sizable minimum liquidity allocation to low disclosure stocks, c lies strictly between zero and unity. In such cases, the marginal insider is indifferent between cross-listing and listing only on the low disclosure exchange.

5.2 Insider Trading Restrictions

An alternative to disclosure standards in reducing expected trading costs is, of course, to curb insider trading. While we have not varied the scope for insider trading in our analysis, it is intuitively apparent that listing decisions would be affected by restrictions on insider trading in a manner similar to differences in the precision of public signals.[25] One way to model this is to assume the precisions of private signals are reduced by such restrictions on insider trading. At the margin, less precise private signals affect an insider's listing decision in the same manner as a more precise public signal, i.e., through a reduction in the posterior variance. Hence, the public policy implications of our analysis also apply to insider trading regulation.

[25] As is the case for disclosure, cross-jurisdictional differences in insider trading rules are substantial. In the United States, insider trading is restricted under Rule 10(b)–5. The Market Surveillance Division of the NYSE, for example, monitors trading and forwards information on suspicious trades to the SEC. Penalties for trading violations, as specified by the 1988 Insider Trading and Securities Fraud Enforcement Act, include treble damages, criminal fines up to $100,000, and imprisonment for up to ten years. Despite this, estimates of insider profits in the highly regulated US market are estimated at $2 billion per year (Fried, forthcoming). In contrast, Austria only criminalized insider trading in 1993; Germany set up its Federal Supervisory Agency as a governing body similar to the SEC and made insider trading a criminal offense in 1994.

6. Conclusion

In this paper, we consider the effects of disclosure requirements on listing decisions and allocation of liquidity across exchanges. Under the assumptions of the basic model, we find that trading concentrates on high disclosure exchanges prompting exchanges to engage in a "race for the top" in setting their disclosure requirements to maximize trading volume. This occurs because corporate insiders, in control of listing decisions, willingly relinquish information advantage for greater disguise of their trades by following liquidity to exchanges where trading costs are lowest. In effect, insiders compete with each other for liquidity to their mutual disadvantage. Similar to models of intertemporal allocations, we find that liquidity traders "flock" to the same firms. However, this force is insufficient to overcome higher trading costs of low disclosure exchanges.

Risk aversion on the part of liquidity traders creates a diversification motive to allocate demands to a low disclosure exchange. However, the marginal firm always prefers to list on the high disclosure exchange to take advantage of the greater depth. Taxes and other restrictions which impede the mobility of liquidity or listings may prompt some firms to list on low disclosure exchanges, notwithstanding the flight of unimpeded liquidity. In fact, conditions exist under which mobile liquidity associated with high disclosure exchanges flows to low disclosure exchanges. However, except in cases where more than half of the liquidity is trapped by firm, exchanges still race for the top in setting their disclosure requirements. While listing costs borne in part by insiders alter their tradeoffs in choosing an exchange, competition between exchanges with fully mobile liquidity still results in both exchanges selecting the highest feasible standards.

Reflecting on the conflict between the NYSE and SEC mentioned at the outset, our analysis suggests less need for concern about differences in disclosure standards between foreign and domestic firms than the spokespersons for these agencies might envision. In particular, it seems insiders bent on profiteering at the expense of liquidity traders would find little advantage to providing low public disclosure when other firms competing for the same pool of liquidity provide high disclosure and liquidity traders rationally anticipate that low disclosure implies high expected trading costs. Accordingly, our model suggests the market for such low disclosure firms trading on otherwise high disclosure exchanges should be quite thin.[26]

Given that exchanges' profits increase in volume, these results suggest exchanges benefit from high disclosure standards. Moreover, one must look beyond flocking, diversification, trapped liquidity, and listing costs to explain the coexistence of high and low disclosure standards in the long run. In the short run, we believe the comparative statics we derive on the allocation of liquidity and (cross-)listing decisions assuming differential disclosure and a variety of impediments to transnational liquidity flows should inform empirical enquiry into international stock trading patterns.

[26] Botosan and Frost (1997) present US evidence that foreign firms traded on the OTC Bulletin Board have much lower volume than comparable exchange-listed firms, which must provide greater disclosure.

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Appendix I. Proofs

Proof of Proposition 1:

Let $\bar{M} = \{m \mid \hat{\lambda}_m \in (0, \infty)\}$. The necessary and sufficient conditions for an allocation over firms in $\bar{M}$ are:

$$\begin{aligned}
g_{mj} &= \frac{\mu_j}{2\hat{\lambda}_m \sigma_u^2}, \\
\sum_{m \in \bar{M}} g_{mj} &= 1, \\
\lambda_m &= \frac{\sigma_{v_m|\theta_{em}}}{2\sigma_u \sqrt{\sum_{n \in N} \hat{g}_{mn}^2}}, \\
\mu_j &\geq 0, \\
\lambda_m &= \hat{\lambda}_m, \\
g_{mj} &= \hat{g}_{mj}.
\end{aligned}$$

Hence,

$$\mu_j = \mu = \frac{2\sigma_u^2}{\sum_{m \in M} {}^1\!/\!_{\lambda_m}},$$

which implies

$$g_{mj} = \frac{\mu}{2\lambda_m \sigma_u^2} \quad \text{for all} \quad j \in N.$$

That is, equilibrium allocations are symmetric when $\hat{\lambda}_m$ is not extreme. Now consider extreme values of $\hat{\lambda}_m$. Suppose $\hat{\lambda}_m = \infty$. Then $g_{mn} = 0$ for $n \in N$, which is symmetric. Let $M' = \{m \mid \hat{\lambda}_m = 0\}$. Then $g_{mn} = 0$ for $m \notin M'$; which implies $g_{mn} > 0$ for some $m \in M'$; which implies $\lambda_m > 0$ for some $m \in M'$, a contradiction. So M' is empty. ∎

Proof of Proposition 5: Consider two exchanges, x and y. Fix the disclosure level on exchange y at $\sigma_{v|y}$ strictly less than the highest disclosure level, i.e., $\sigma_{v|y} > \underline{\sigma}_v$. From Proposition 3, all liquidity is allocated to exchange x if $\sigma_{v|x} \geq \sigma_{v|y} dM$. Such a $\sigma_{v|x}$ always exists because because $d < {}^1\!/\!_M$. Thus no equilibrium exists in which both exchanges choose disclosure levels below $\underline{\sigma}_v$.

If both exchanges select the highest disclosure standard, then, by assumption, each exchange has half of the volume, i.e., $\frac{1}{2}N$. These disclosure strategies by the exchanges are a Nash equilibrium if a defection by one exchange to the lowest level of disclosure is dominated. That is, the volume received by an exchange from selecting a low disclosure level must be less than than the volume received by either exchange if both exchanges select the highest disclosure level, i.e.,

$$df_2MN < \tfrac{1}{2}N. \tag{I.1}$$

Consider a defection to a completely uninformative public signal, σ_v. From Proposition 3, the fraction of firms listing on exchange 1, given exchange 1 chooses the highest disclosure and exchange 2 chooses the lowest disclosure, is

$$f_1 = \min\left\{1, \frac{\underline{\sigma}_v(1-dM)}{(\sigma_v - \underline{\sigma}_v)dM}\right\}.$$

Since $f_2 = 1 - f_1$, (I.1) reduces to (10). ▮

Derivation of an insider's utility function in the case of risk aversion:

We can derive (12) by computing the mean and variance of the argument of the utility function in (11):

$$\begin{aligned}
&E_{u_1,\ldots,u_{n-1},u_{n+1},\ldots,u_N} E_{v_m|\theta_{em}} \left[\sum_{m\in M} g_{mn}u_n \left(v_m - p_m(y_m, \theta_{em})\right)\right] \\
&= \sum_{m\in M} E_{u_1,\ldots,u_{n-1},u_{n+1},\ldots,u_N} E_{v_m|\theta_{em}} \Bigg[g_{mn}u_n \\
&\qquad \left(v_m - \left(v_{\theta_m} + \lambda_m \left(x_m(v_m, \theta_{em}) + \sum_{n\in N} g_{mn}u_n\right)\right)\right)\Bigg] \\
&= -\, u_n^2 \sum_{m\in M} \lambda_m g_{mn}^2,
\end{aligned}$$

and,

$$
\begin{aligned}
&\operatorname{Var}\left[\sum_{m\in M} g_{mn}u_n\left(v_m - p_m(y_m,\theta_{em})\right)\right] \\
=&\sum_{m\in M} g_{mn}^2 u_n^2 \operatorname{Var}\left[\left(v_m - p_m(y_m,\theta_{em})\right)\right] \quad \text{since the r.v.s are independent over } m \\
=&u_n^2\sum_{m\in M} g_{mn}^2 \operatorname{Var}\left(v_m - v_{\theta_m} - \lambda_m\left(x_m(v_m,\theta_{em}) + \sum_{k\in N} g_{mk}u_k\right)\right) \\
=&u_n^2\sum_{m\in M} g_{mn}^2\left[\operatorname{Var}\left(v_m - v_{\theta_m} - \lambda_m x_m\left(v_m,\theta_{em}\right)\right) + \lambda_m^2\operatorname{Var}\left(\sum_{\substack{k\in N\\ k\neq n}} g_{mk}u_k\right)\right] \\
=&u_n^2\sum_{m\in M} g_{mn}^2\left[\operatorname{Var}\left(\left(1-\lambda_m\beta_m\right)\left(v_m - v_{\theta_m}\right)\right) + \lambda_m^2\sigma_u^2\sum_{\substack{k\in N\\ k\neq n}} g_{mk}^2\right] \\
=&u_n^2\sum_{m\in M} g_{mn}^2\left[\left(1-\lambda_m\beta_m\right)^2\sigma_{v_m|\theta_{em}}^2 + \lambda_m^2\sigma_u^2\sum_{\substack{k\in N\\ k\neq n}} g_{mk}^2\right].
\end{aligned}
$$

∎

Proof of Proposition 6:

$$P_1(M_1,M_2) > P_2(M_1,M_2) \text{ iff } \sigma_{v|1}g_{m_1} > \sigma_{v|2}g_{m_2} \text{ iff}$$

$$\sigma_{v|1}\left(\sigma_{v|2}^2 + \frac{4N}{2N-1}\,\frac{(\sigma_{v|2}-\sigma_{v|1})M_2}{r\sigma_u\sqrt{N}}\right) > \sigma_{v|2}\left(\sigma_{v|1}^2 + \frac{4N}{2N-1}\,\frac{(\sigma_{v|1}-\sigma_{v|2})M_1}{r\sigma_u\sqrt{N}}\right)$$

iff

$$\sigma_{v|1}\sigma_{v|2}^2 - \sigma_{v|1}^2\sigma_{v|2} > \frac{4N}{2N-1}\,\frac{1}{r\sigma_u\sqrt{N}}\left(\sigma_{v|2}(\sigma_{v|1}-\sigma_{v|2})M_1 - \sigma_{v|1}(\sigma_{v|2}-\sigma_{v|1})M_2\right)$$

iff

$$\sigma_{v|1}\sigma_{v|2}(\sigma_{v|2}-\sigma_{v|1}) > \frac{4N}{2N-1}\,\frac{1}{r\sigma_u\sqrt{N}}\left((\sigma_{v|2}M_1 + \sigma_{v|1}M_2)(\sigma_{v|1}-\sigma_{v|2})\right)$$

iff (recall $\sigma_{v|1} < \sigma_{v|2}$, so dividing through by $\sigma_{v|2} - \sigma_{v|1}$ does not flip the direction of the inequality)

$$\sigma_{v|1}\sigma_{v|2} > -\frac{4N}{2N-1}\,\frac{1}{r\sigma_u\sqrt{N}}(\sigma_{v|2}M_1 + \sigma_{v|1}M_2)$$

The left hand side is clearly positive. The right hand side is always negative. ∎

Proof of Proposition 7:

The first order conditions associated with the Lagrangian imply:

$$g_{mn} = \begin{cases} \frac{\mu_n+\gamma_n}{2\sigma_u^2\hat{\lambda}_m}, & \text{if } m \in M_e; \\ \frac{\mu_n}{2\sigma_u^2\hat{\lambda}_m}, & \text{otherwise.} \end{cases} \tag{I.2}$$

where μ_n and γ_n are the multipliers on (3) and (14), respectively. If constraint (14) is not binding and $\hat{\lambda}_m \in (0, \infty)$ for $m \in M$, an equilibrium allocation has

$$g^*_{mn} = \frac{1}{\lambda_m \Lambda(M)} \quad \text{for } n \in N. \tag{I.3}$$

If (14) is binding, then substituting (2) into constraints (3) and (14) yields two linear equations in μ_n and γ_n. Solving for μ_n and γ_n in terms of the exogenous parameters and $\{\hat{\lambda}_m\}_{m\in M}$ implies

$$g^*_{mn} = \begin{cases} \frac{D_e}{\hat{\lambda}_m\Lambda(M_e)}, & \text{if } m \in M_e; \\ \frac{1-D_e}{\hat{\lambda}_m\Lambda(M\backslash M_e)}, & \text{otherwise.} \end{cases} \tag{I.4}$$

Constraint (14) is binding whenever the solution to (2) subject only to (3) differs from the solution when (14) also applies. That is, (14) is binding when

$$\frac{1}{\lambda_m\Lambda(M)} < D_e\frac{1}{\lambda_m\Lambda(M_e)} \quad \text{or,}$$
$$\Lambda(M_e) < D_e\Lambda(M). \tag{I.5}$$

Proof of part (i)

Combining (4), (I.3), and (I.4) for $m \in M_1$ implies that in equilibrium

$$\lambda_m = \frac{\sigma_{v|1}}{2\sigma_u}\left(\sum_{n\in N_1} \max\left\{\left(\frac{1}{\lambda_m\Lambda(M)}\right)^2, \left(\frac{D_1}{\lambda_m\Lambda(M_1)}\right)^2\right\}\right.$$
$$\left. + \sum_{n\in N_2} \min\left\{\left(\frac{1}{\lambda_m\Lambda(M)}\right)^2, \left(\frac{1-D_2}{\lambda_m\Lambda(M_1)}\right)^2\right\}\right)^{-1/2}.$$

Collecting common factors and taking the reciprocal of each side yields

$$\Lambda(M) = \frac{2\sigma_u}{\sigma_{v|1}}\sqrt{N_1 \max\left\{1, \frac{D_1\Lambda(M)}{\Lambda(M_1)}\right\}^2 + N_2 \min\left\{1, \frac{(1-D_2)\Lambda(M)}{\Lambda(M_1)}\right\}^2}.$$

Similarly, for $m \in M_2$,

$$\Lambda(M) = \frac{2\sigma_u}{\sigma_{v|2}}\sqrt{N_1 \min\left\{1, \frac{(1-D_1)\Lambda(M)}{\Lambda(M_2)}\right\}^2 + N_2 \max\left\{1, \frac{D_2\Lambda(M)}{\Lambda(M_2)}\right\}^2}.$$

Equating the left hand sides of these two equalities gives

$$\left(\frac{\sigma_{v|1}}{\sigma_{v|2}}\right)^2\left(N_1 \min\left\{1, \frac{(1-D_1)\Lambda(M)}{\Lambda(M_2)}\right\}^2 + N_2 \max\left\{1, \frac{D_2\Lambda(M)}{\Lambda(M_2)}\right\}^2\right)$$
$$= N_1 \max\left\{1, \frac{D_1\Lambda(M)}{\Lambda(M_1)}\right\}^2 + N_2 \min\left\{1, \frac{(1-D_2)\Lambda(M)}{\Lambda(M_1)}\right\}^2. \quad \text{(I.6)}$$

Now we show by contradiction that all mobile liquidity from the low disclosure exchange is allocated to the high disclosure exchange. Suppose (14) is not binding for $e = 2$. Then (5) does not hold for $e = 2$, i.e., $1 > D_2\Lambda(M)/\Lambda(M_2)$. Then (I.6) reduces to:

$$\left(\frac{\sigma_{v|1}}{\sigma_{v|2}}\right)^2\left(N_1 \min\left\{1, \frac{(1-D_1)\Lambda(M)}{\Lambda(M_2)}\right\}^2 + N_2\right)$$
$$= N_1 \max\left\{1, \frac{D_1\Lambda(M)}{\Lambda(M_1)}\right\}^2 + N_2.$$

Since $\sigma_{v|1} < \sigma_{v|2}$, this implies

$$\min\left\{1, \frac{(1-D_1)\Lambda(M)}{\Lambda(M_2)}\right\} > \max\left\{1, \frac{D_1\Lambda(M)}{\Lambda(M_1)}\right\},$$

which plainly cannot be.

Proof of part (ii)

For $m \in M_1$, (4) implies

$$\lambda_m = \frac{\sigma_{v|1}}{2\sigma_u\sqrt{\sum_{n\in N_1}\left(\frac{D_1}{\lambda_m\Lambda(M_1)}\right)^2 + \sum_{n\in N_2}\left(\frac{1-D_2}{\lambda_m\Lambda(M_1)}\right)^2}}.$$

Simplifying,

$$\Lambda(M_1) = 2\frac{\sigma_u}{\sigma_{v|1}}\sqrt{N_1D_1^2 + N_2(1-D_2)^2}.$$

Hence the conjectures are fulfilled and the constraints are binding when (I.5) holds for exchange 1,

$$2\frac{\sigma_u}{\sigma_{v|1}}\sqrt{N_1D_1^2 + N_2(1-D_2)^2} < D_1\left(2\frac{\sigma_u}{\sigma_{v|1}}\sqrt{N_1D_1^2 + N_2(1-D_2)^2} + 2\frac{\sigma_u}{\sigma_{v|2}}\sqrt{N_1(1-D_1)^2 + N_2D_2^2}\right),$$

since $\Lambda(M) = \Lambda(M_1) + \Lambda(M_2)$. The inequality reduces to (15) for exchange 1. Similarly, we have (16) for exchange 2. To complete the proof, the reader can easily check that parameters exist which satisfy these conditions, for instance $D_1 = .6$, $D_2 = .9$, $N_1 = 10$, $N_2 = 20$, $\sigma_{v|1} = .2$, and $\sigma_{v|2} = .6$.

Proof of part (iii)

If (14) is binding for $e = 2$ but not for $e = 1$, then (I.5) implies that (I.6) reduces to (17) where $X = \Lambda(M_1)/\Lambda(M)$. There is a unique solution to this equation in $(0,1)$ since the left-hand side of (17) is increasing in X over this range while the right-hand side is decreasing in X. Moreover, both sides are continuous in X; the left-hand side of (17) is finite at 0 and unbounded at 1; and, the right-hand side of (17) is unbounded at 0 and finite at 1. That $X > D_1$ follows from (I.5). ∎

Proof of Proposition 9: Suppose the level of disclosure on exchange 1 is higher than the level of disclosure on exchange 2, i.e., $\sigma_{v|1} < \sigma_{v|2}$. Let $X = \sum_{m \in M_x} g^*_{mn}$ for $n \in N_1$ denote the fraction of the liquidity shock a trader situated at the exchange 1 optimally allocates to firms listed on that exchange. From (17) we have $D_2 > 1 - X$.

Let $Y = \sum_{m \in M_x} g^*_{mn}$ for $n \in N_1$ and $Z = \sum_{m \in M_x} g^*_{mn}$ for $n \in N_2$ denote the fraction of the liquidity shock a trader situated at the exchange 1 and 2, respectively, optimally allocates to firms listed on that exchange given both exchanges choose the (same) highest feasible disclosure standard. From Proposition 2, the symmetry property assures that $1 - Y = Z$. For the allocations to be feasible, it must also be that $Y \geq D_1$ and $Z \geq D_2$.

For both exchanges, the strategy of adopting the highest feasible disclosure standard is an equilibrium if the volume on the exchange is at least as high as it would be were one exchange, say exchange 2, to unilaterally lower its disclosure. This is straightforward to show from the relationships established above. If both exchanges adopt the same level of disclosure, the volume on exchange 2 is

$$\begin{aligned}(1 - Y)N_1 + ZN_2 &= ZN_1 + ZN_2 \\ &\geq D_2N_1 + D_2N_2 \\ &> (1 - X)N_1 + D_2N_2,\end{aligned}$$

which is the volume on exchange 2 when the disclosure standard on exchange 2 is below the disclosure standard on exchange 1. ∎

Proof of Proposition 11: The proof parallels the proof from Proposition 5. Consider two exchanges, x and y. Fix the disclosure level on exchange y at $\sigma_{v|y}$ strictly less than the highest disclosure level, i.e., $\sigma_{v|y} > \underline{\sigma}_v$. From Proposition 10, all liquidity is allocated to exchange x if $\sigma_{v|x} \geq \sigma_{v|y} dM + JM$. Such a $\sigma_{v|x}$ always exists because because $d < {}^1\!/_M$ and $J \to 0$ as $\sigma_{v|x} \to \sigma_{v|y}$ because C increases monotonically in the disclosure level by assumption. Thus no equilibrium exists in which both exchanges choose disclosure levels below $\underline{\sigma}_v$.

If both exchanges select the highest disclosure standard, then, by assumption, each exchange has half of the volume, i.e., ${}^1\!/_2 N$. These disclosure strategies by the exchanges are a Nash equilibrium if a defection by one exchange to the lowest level of disclosure is dominated. That is, the volume received by an exchange from selecting a low disclosure level must be less than than the volume received by either exchange if both exchanges select the highest disclosure level, i.e.,

$$df_2 MN < {}^1\!/_2 N. \tag{I.7}$$

Consider a defection to a completely uninformative public signal, σ_v. From Proposition 10, the fraction of firms listing on exchange 1, given exchange 1 chooses the highest disclosure and exchange 2 chooses the lowest disclosure, is

$$f_1 = \min\left\{1, \frac{\underline{\sigma}_v(1-dM)}{(J+(\sigma_v-\underline{\sigma}_v)d)\,M}\right\}.$$

Since $f_2 = 1 - f_1$, (I.7) reduces to (21). ▮

Appendix II. Notation

v_m	end-of-period value of firm m
u_n	liquidity demand of trader n
α	endowed ownership stake of each insider in the firm with which she is associated
β_m	trading intensity of the insider associated with firm m
λ_m	per unit traded price adjustment chosen by market maker for firm m
θ_{em}	noisy public disclosure of the value of firm m listed on exchange e
M	number (or set) of firms
M_e	number (or set) of firms listed on exchange e
c	fraction of firms that cross-list
f_e	fraction of firms listed on exchange e
N	number (or set) of liquidity traders
N_e	number (or set) of liquidity traders associated with exchange e
g_{mn}	fraction of liquidity trader n's demand allocated to firm m
σ_u^2	variance of a liquidity trader's demand
$\sigma^2_{v_m\|\theta_{em}}$	posterior variance of the value of firm m conditional on signal θ_{em}
$\sigma_{v\|e}$	abbreviation for $\sigma_{v_m\|\theta_{em}}$
d	minimum fraction of demands each liquidity trader must allocate to every firm
D_e	minimum fraction of demands each liquidity trader associated with exchange e must allocate to firms listed on exchange e
r	liquidity traders' coefficient of risk aversion
$C(\sigma_{v\|e})$	the cost of meeting the disclosure level implied by posterior variance $\sigma_{v\|e}$