Competition and Co-operation Among Exchanges: A Theory of Cross Listing and Endogenous Listing Standards

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Abstract

We analyze firms' choice between exchanges to list their equity (including multiple listings), and exchanges' choice of listing standards for firms which apply for listing, in an environment of competition and co-operation among exchanges. We model an equity market characterized by asymmetric information, where outsiders can reduce their informational disadvantage relative to insiders by producing (noisy) information about firms at a cost. Exchanges are populated by two kinds of investors: sophisticated investors, with a cost advantage in producing information ("low-cost investors"), and ordinary investors, without such a cost-advantage ("high-cost investors"); the proportions of these two kinds of investors vary across exchanges. While firms are short-lived agents, exchanges are long-lived, value-maximizing agents, whose stringency in their listing and disclosure standards evolve over time. Exchanges also use their listing standards as a tool in competing with other exchanges for listings by firms. However, outsiders can partially infer the rigor of an exchange's listing policy by studying the subsequent performance of firms which have obtained listing there. The listing standards chosen by an exchange therefore affects its "reputation." The listing choices of firms between exchanges, the valuation effects of listings on firm equity, and exchanges' listing standards emerge endogenously in equilibrium. Our model has implications for: the relationship between firm characteristics and the benefits from cross (and dual) listing; the price effects of cross listings; the relationship between cross listing and financial analyst following; the relationship between an exchange's reputation and its listing standards; the impact of competition on an exchange's listing standard; the impact of an alliance between exchanges on the listing standards of the allied exchange and of exchanges competing with it; and for the optimal regulation of exchanges.

1. Introduction

The recent process of integration in international capital markets has led a growing number of firms to seek listing of their equity outside their country of origin. Correspondingly, as more venues have become available for firms to list their equity, stock exchanges have been exposed to an unprecedented level of competition for listing. In this paper we develop a theory of the determinants of a firm's decision of where to list its equity among several possible exchanges. We study how the recently intensified competition (as well as co-operation in the form of alliances or mergers among stock exchanges) affect the listing standards chosen by these exchanges, and thereby the listing decisions of firms.

International listing of firm's equity has now become a rather common phenomenon. Many European firms are obtaining listings on the New York Stock Exchange (NYSE), and many firms from various emerging market countries (e.g., Israel) are obtaining listings not only on the NYSE, but also on various other American and European exchanges.[1] These may include firms going public for the first time (Global Initial Public Offerings) or firms which are already public choosing to list equity in an additional exchange (dual listing). While there is some evidence documenting the benefits of such international listing (in terms of increases in shareholder wealth), there has been relatively little theoretical analysis of the factors affecting such benefits, with the notable exception of the market segmentation literature.[2] Indeed, there has been few analyses of the factors driving a firm's choice of equity market to list, either between domestic exchanges (for example, Nasdaq National Market vs. NYSE) or internationally (for example, should a Swedish firm choosing to list in a foreign equity market list it on the London Stock Exchange (LSE) or the NYSE?).

A mirror image of the above phenomenon has been the competition between various major exchanges, both in the U.S and in Europe, to attract listings from firms. For example, the NYSE and the LSE have engaged in vigorous competition to attract listings from companies in third countries (especially companies from developing or "emerging" economies). A natural question that arises in this context is the effect of such competition on the "listing standards" set by these exchanges. In order to answer such

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[1]A foreign company may have its existing securities listed in the U.S in the form of an American Depository Receipt (ADR). There are three levels of ADRs: Level I (for over-the-counter trading); Level II (for a national securities exchange or NASDAQ listing); foreign firms may raise new capital in a public offering using level III ADRs. Alternatively, foreign firms may have their shares listed directly in the U.S. ADRs Level II and III are subject to the registration and reporting requirements of the Securities Act of 1933 and the securities Exchange Act of 1934. (See Salomon Brothers (1994) or Fuerst (1996) for institutional details).

[2]Some examples of the market segmentation literature bearing on this issue are Stapleton and Subrahmanyam (1977), Stulz (1981), Errunza and Losq (1985), and Alexander, Eun, and Janakiraman (1987).

questions, however, one has to analyze the determinants of exchanges' listing standards in the first place.

The objective of this paper is to develop a theoretical analysis which allows us to answer both kinds of questions (i.e., regarding listing choice by firms and the choice of listing standards by exchanges), in a unified framework. Some of the issues that we address in this paper are as follows: (i) What are the incentives for firms in one country or geographical region to obtain a listing in another country? (ii) What determines an exchange's choice of listing requirements, and what are the consequences of an exchange's listing standard choice for firm-valuation as well as for the exchange itself? (iii) Does it pay for a firm to be listed on multiple exchanges? (iv) How can the notion of the "reputation" of an exchange be operationalized, and how does it drive the choice of firms of an exchange to list? How is the reputation of an exchange related to its own choice of listing standard? (vi) How do exchanges compete for firms' listings, and what is the effect of this competition on exchanges' listing standards?[3]

It is useful to clarify here what we mean by the "listing standards" of an exchange. Exchanges usually have a number of minimum requirements regarding their profitability record, number of shares (float) and minimum market capitalization, etc., on firms applying for listing (and for continuing to list), and such requirements tend to be more stringent in more reputable exchanges.[4] However, the more relevant requirements relate to the regulations regarding the form and content of required firm disclosures, and the stringency with which any violations in disclosure and other securities regulations are monitored and enforced. Usually, exchanges which are more stringent in their listing requirements, are also more exacting in their disclosure requirements, as well in the policing of any violations in these requirements. Clearly, firms need to abide by these latter requirements as well if they are to continue to remain listed on an exchange. Thus, throughout this paper, we use the term "listing requirements" in this broader sense, to cover not only the initial listing requirements of the exchange, but also the stringency of their disclosure and other regulations, and the rigor with which these regulations are enforced (as will become clear from our approach to modeling these requirements).

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[3]Our analysis is also aimed at shedding light on the empirical evidence that has accumulated in this area regarding firm's choice between various exchanges. Several interesting questions that have arisen in this context, and to which clear answers are not available based on the existing research. For example: What is the wealth effects (on firm equity holders) of a dual listing (if any)? Will such effects be significantly different for a foreign firm listing on a U.S exchange (say, the NYSE) and a U.S firm listing on a foreign exchange (say, the LSE)?

[4]It is also worth noting that listing is not automatic for firms meeting these minimum initial listing requirements, and that exchanges have the discretion to reject applications for listing even from firms that meet these minimum requirements.

Developing a theoretical framework capable of addressing the questions discussed above is important, since the answers to such questions determine a firm's costs in accessing capital markets in general, and the equity market in particular. This has assumed increased significance in the light of the recently accelerating pace of economic integration around the world, especially in Europe (driven by the introduction of the Euro). Several exchanges in Europe and in the U.S. have either entered into tie-ups with each other, or are considering them.[5] In addition to providing answers to some of the questions discussed above, our analysis has implications for the advantages and disadvantages of such tie-ups. Further, our analysis sheds some light into the characteristics of those exchanges that will emerge as winners, in contrast to those that will face decreasing listings (and eventually go out of business) in the current environment of competition (as well as some co-operation) between exchanges.

The general setting of our analysis is an equity market characterized by asymmetric information, where insiders have private information about firm value. Outsiders, however, can reduce this informational disadvantage by producing (noisy) information at a cost. There are two kinds of investors: those with a cost advantage in producing information about the true firm value ("low-cost investors") and those who do not have such a cost-advantage ("high-cost investors"). As a practical matter, one can think of low-cost investors as financial analysts, portfolio managers, or other professional investors knowledgeable about a given industry or firm, and who therefore have special expertise in valuing the firm; high-cost investors are ordinary investors without any such expertise.

Five important ingredients drive our analysis in the above setting. First, from the point of view of any given firm, the number of low-cost information producers (who have a cost advantage in evaluating that firm) may vary from exchange to exchange. For example, investors with expertise (and therefore a cost advantage) in evaluating technology companies may dominate trading at the NASDAQ; investors with expertise in evaluating Swedish companies may be dominant at Stockholm (but perhaps are far fewer in number at other exchanges). Second, different exchanges have different listing and disclosure requirements, which not only affect the kind of firms that are listed, but also the ongoing policing of various financial disclosures by the

[5]One example of such a tie-up was the proposed alliance (later aborted) between the London and Frankfurt Stock Exchanges. Another example is the merger between the Amsterdam, Brussels and Paris Stock Exchanges, completed in September 2000. In the U.S., Instinet, the electronic trading system, and its rival, Island ECN, have entered into merger talks, and the competitive threat posed by such a merger to the Nasdaq has been much talked about: see, e.g., a recent news story titled, "Rivals' Merger Talks Threaten Nasdaq,"(*Financial Times*, May 17, 2002).

firm, and therefore the precision of the information available to outsiders in evaluating the firm.[6] Third, the rigor with which the listing and disclosure policies of an exchange are implemented evolves over time, and is not fully observable to outsiders; however, outsiders can assess the stringency of an exchange's true listing procedure over time by studying the performance of firms listed in prior years. This performance, therefore, affects the exchange's "reputation." Fourth, since these listing and disclosure requirements can be altered by the exchange over time, the possibility of gaining or losing reputation affects the endogenous choice of listing standards by the exchange.[7] Fifth, exchanges may alter these listing standards to compete with other exchanges for listing candidates (or as a result of an alliance or a merger with another exchange), taking into account the impact of any alteration of these standards on their reputation.[8]

We develop our analysis in two steps. First, we develop a theory of the determinants of a firms's listing decision, which depends on the benefits that a firm expects to obtain from listing at various exchanges (as well as from multiple listings). We show that firms benefits from the presence at an exchange of more investors who can produce information about them at a low cost, and from an exchanges's being more stringent in its listing and disclosure requirements, which enhances such investors' effectiveness in producing information. Based on the above the theory of the listing choice of firms, we then turn to an analysis of an exchange's equilibrium choice of listing standard. We examine how competition from other exchanges (as well as co-operation with them) affect this listing standard choice. We show that exchanges have an incentive to develop a reputation for stringency in their listing standard, since they benefit from such a reputation for

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[6]Foreign companies are required to register and report continuously under the Exchange Act. Their annual reports must confirm either to U.S GAAP or to the accounting standards of their own country, but with partial reconciliation to U.S GAAP. Even in the latter case, the disclosure required is much more than in most foreign market listings. Further, the financial statements of a foreign company conducting its first public offering in the U.S must either follow U.S GAAP or provide a *full* reconciliation to U.S GAAP.

[7]That exchanges' reputations are affected by problems involving firms listed on them, and take this into consideration in designing their listed standards is illustrated by a news story titled, "YBM Probe Leaves Toronto exchange Red-faced, a Year after Bre-X Scandal," (*Wall Street Journal*, June 1998). We quote: "This time, damage to Canada's biggest stock exchange's reputation stems from YBM Magnex International Inc., a canadian-registered industrial magnet maker, that is the focus of an investigation by the federal bureau of investigation....John Carson, the TSE's executive vice president, market regulation, defended the exchange's screening process for new listings. He added that, since the Bre-X debacle, the exchange has beefed up its disclosure requirements for mining companies." Another, more recent example along the same lines is provided by Germany's Neuer Market, as reported in the news story, titled, "Can the Neuer Market Survive the Onslaught?" (*Financial Times, April 27, 2002*). The news story reports that officials at the Neuer Market have been pressed very hard to tighten the exchange's listing standards after a period of very bad performance by firms listed there.

[8]The vigorous competition between two U.S exchanges for listings from foreign firms, and the kinds of trade-offs involved in firm's choice between exchanges studied in this paper are illustrated by the following news story, titled, "U.S Markets Battle to List Foreign Firms,"(*Wall Street Journal*, September, 1997). We quote: "At the end of a routine marketing trip to India last May, James E. Shapiro, the New York Stock exchange's Managing Director for international listings and research, abruptly changed his schedule. He jetted to the southern city of Bangalore to give a pitch to the software company Infosys that was believed to be close to a deal to list ADRs on the Nasdaq Stock market.'He made a presentation and answered a lot of questions about why the New York Stock Exchange should be preferable to the NASDAQ,' says N.R. Narayana Murthy, Infosys Chairman." Infosys later chose the NASDAQ over the NYSE.

stringency by attracting firms seeking a listing. Further, we show that competition among exchanges will not necessarily result in a race either to the top or to the bottom in terms of listing standards, but may result in an endogenous segmentation of the market for listings. Rather, a likely outcome of competition among exchanges is that high reputation exchanges set high listing standards and become first-tier stock markets, while low reputation exchanges set lower listing standards and become lower tier markets. Finally, we analyze the incentives of two exchanges to enter into an alliance or merger in order to increase their competitive position, and solve for the impact of such a merger on not only the listing standard of the combined exchange, but also on the listing standards of other exchanges competing with the allied exchange.

Our research is related to several strands in the theoretical and empirical literature. One implication of the large market-segmentation literature is that cross listing can facilitate improved risk-sharing, thereby reducing expected return (see, e.g., Stulz (1981), and Stapleton and Subrahmanyam (1977)). Chowdhry and Nanda (1991) introduce multi-market trading into a Kyle (1985)-type model in which the informed trader has several avenues to exploit his private information. Their focus, however, is on the effect such trading on market liquidity and informativeness of prices, whereas ours is on the listing decisions by firms and the listing standards of exchanges.[9,10]Two related contemporaneous papers are Huddart, Hughes, and Brunnermeier (1998) and Foucault and Parlour (1998). The former paper uses Kyle-type setting where the firm's listing choice is driven by the insider's desire to list in the exchange with the greatest number of liquidity traders, enabling him to mask his trades. The latter paper focuses on the relationship between trading costs and listing fees, and predicts an inverse relationship between the two.[11] In contrast to this literature, in our paper the firm's listing choice is driven by the presence (or otherwise) of skilled analysts and investors in various

[9]In this paper, we have chosen not to focus on listing choices by firms driven purely by considerations of market micro-structure (e.g., a firm in one country choosing to cross-list at an exchange in another purely because it believes that the trading system used in the foreign exchange is superior). While such considerations may influence firms' listing decisions, they do not seem to be primary driving force in firms seeking to cross-list their securities.

[10]A purely liquidity-based rationale for cross-listing that has often been advanced is the argument that some capital markets simply have poor liquidity, so that cross-listing in a market with greater liquidity can reduce the liquidity-premium, and therefore expected return. However, the precise meaning of what "liquidity" means in such arguments is often unclear, and also why some markets should inherently have less liquidity (especially in the context of trading the equity of companies based in, and doing business in, the same country as the one in which the exchange is located).

[11]Santos and Scheinkman (1998) develop a model of competition between exchanges in which exchanges design securities in order to attract clienteles and maximize profits. Their focus, however, is on the design of margin requirements (set to protect investors from potential defaults; they do not study the listing decisions of firms or the choice of listing standards by exchanges. Our paper is also related to the literature on IPOs and other stock issues in an environment of asymmetric information or information production (see, e.g., Allen and Faulhaber (1989) or Chemmanur (1993)).

markets, and the extent of information available to these investors about the firm.

Our work is also related to the empirical literature that has looked at the determinants of choice of foreign exchange listing choice by firms (see, e.g., Saudagaran (1988), Saudagaran and Biddle (1995)), Blass and Yafeh (2000), and Pagano, Roell and Zechner, 2002), the large empirical literature on the announcement effects on the stock price of foreign firms listed on U.S exchanges (see, e.g., Jayaraman, Shastri, and Tandon (1993), Forester and Karolyi (1993), Alexander, Eun, and Janakiraman (1991), and Miller (1999)) and also the empirical literature focussing on the announcement and other effects of overseas listing by U.S firms (e.g., Howe and Kelm (1987), and Lau, Diltz and Apilado (1994)).

The paper is organized as follows. In the next section (section 2) we examine a single-period model where exchanges' listing standards and listing fees are exogenous. We then study the equilibrium of this basic model under increasingly less restrictive assumptions regarding the listing choices available to firms. Section 3 describes the equilibrium assuming that the firm can list on only one exchange. Section 4 allows the firm to choose between exchanges (while not allowing dual listing). Section 5 studies the equilibrium with dual listing allowed as well. We then build on the single-period model to develop a dynamic (two-period) model to endogenize exchanges' listing policies and fees (presented in sections 6, 7, and 8). In this dynamic model, exchanges act as long-lived agents who maximize the present value of their cash flows from listing fees (which are affected by considerations of building and preserving exchange reputation). In section 6, the exchange is a monopolist, and determines its listing standard taking into account considerations of reputation alone. In section 7, two exchanges compete with another, so that the listing standard chosen by each exchange (and also the listing decisions of firms) emerges from considerations of exchange reputation interacting with competition among exchanges. Section 8 analyzes the effect of co-operation as well as competition among exchanges: we study how a merger or alliance between exchanges affects the listing standards chosen by the combined exchange as well as exchanges competing with it, and also study the listing decisions of firms in this environment. Section 9 describes the empirical and other implications of our model. Section 10 concludes. The proofs of all propositions are confined to the appendix.

2. The Model

The basic (single-period) model consists of two dates. At time 0, a risk-neutral entrepreneur or firm has monopoly access to a single project. The project requires a certain investment at time 0, which the

entrepreneur wishes to raise from outside investors through an initial public offering (IPO) of equity, since the firm has no internal capital available. He can obtain this capital by listing his firm's shares either in exchange X (the domestic market) alone, in exchange Y (a foreign market) alone, or through dual listing (i.e., listing in both exchanges X and Y). To begin with, the equity in the firm is assumed to be divided into a large number of shares m, all owned by the entrepreneur. The entrepreneur now sells a certain number of additional shares to outsiders in an IPO, after listing the equity in one or more exchanges, thus lowering the fraction of equity that he holds in the firm. At time 1, the project pays off a certain cash flow, which depends on project (firm) quality or "type," f, about which the entrepreneur has private information. We assume that the risk-free rate of return is zero.

Thus, there is only one round of firms entering the equity market in the basic model. In sections 6, 7, and 8, where we build on this basic model to develop a dynamic (two period, three date) model, we allow a new round of firms to enter the equity market at time 1, with their cash flows realized at time 2. In this model, exchanges are long-term (two period) players, going from time 0 to time 2, while firms are short-term (one-period) players. The sequence of events in the dynamic model is depicted in figure 1.

2.1 The Entrepreneur's Private Information and Project Technology

Projects are of two types: "good" (f = G) or "bad" (f = B); type G projects have a greater expected value of time 1 cash flow than type B projects. The time 1 cash flow from the project, denoted by $v_f(\iota)$, depends on project quality as well as upon the amount invested in the project at time 0, denoted by ι. This cash flow is given by the following investment technology:

$$\begin{aligned} v_f(\iota) = k_f \iota \quad \text{for } \iota < I, \quad v_f(\iota) = k_f I \quad \text{for } \iota \geq I; \\ f \in \{G, B\}, \quad \textit{and} \quad k_G > k_B > 1. \end{aligned} \tag{1}$$

From (1), we can see that the firm's technology is such that any amount invested at time 0 lower than or equal to a certain upper limit I yields a time 1 cash flow k_f times ι, $f \in \{G, B\}$. However, for investment amounts above I, the cash flow generated remains at $k_f I$, so that no entrepreneur chooses an investment level above this amount I. Further, for any given level of investment, type G firms yield a greater expected cash flow compared to type B firms. For convenience, denote by V_G and V_B the entrepreneur's time 0 expectation (for the type G and the type B firm respectively) of his firm's time 1 cash flow, at the full investment level I (i.e., $V_G \equiv k_G I$,

and $V_B \equiv k_B I$). The objective of the entrepreneur in making the firm's listing and investment decisions is to maximize the expected value of the time 1 cash flow accruing to him.

2.2 Outsiders' Evaluation Technology and Strategies

Outside investors have less information than entrepreneurs about the true quality or type of the firm approaching them for capital. They do not observe firm type, but only the prior probability ω of the firm being of type G. However, when offered equity in any firm, they can choose to expend additional resources and produce more information about the firm, in order to reduce their informational disadvantage. We model this information production by outsiders as follows. At a cost $c > 0$, outsiders can obtain a noisy "evaluation" (e) of the firm, which can have one of two outcomes: "good" (e = g) or "bad" (e = b). Further, we assume that the precision of their evaluation technology is such that, for any investor producing information:

$$\text{Prob}\{e = g \mid f = G\} = 1, \quad \text{Prob}\{e = g \mid f = B\} = 1 - \gamma, \quad 0 < \gamma < 1. \tag{2}$$

Thus, all good firms get good evaluations; however, bad firms may also get good evaluations with a certain probability $(1 - \gamma)$ so that the evaluation is noisy. Thus, the precision of the evaluation is captured by γ. We also assume that, when a number of investors produce information about a type B firm, a fraction $1 - \gamma$ of these investors obtain good evaluations, while the remaining fraction γ obtain bad evaluations.[12]

The outsiders' evaluation cost depends on several factors. First, the magnitude of c depends on the amount of information already available in the public domain about the firm and its management, in the market where the firm is listed. For example, an established software firm such as Microsoft, with a track-record of successfully developing and implementing products might be easier to evaluate (and hence have a lower c) than a start-up software firm with great potential, but no track-record at all for successful product-implementation. A second (related) factor may be the familiarity of investors in a given market with the firm, its products, its technology, or its management. For example, Swedish investors may find it much easier than U.S investors to evaluate a Swedish natural-resources firm which has not done any business in the U.S, perhaps because the firm is based in Sweden, and they (unlike U.S investors) have been familiar with its

[12]If we were to assume instead that investors producing information about a type B firm obtain independent signals, the expected value of the fraction of these investors obtaining good evaluations will still remain γ. However, in this case, many of our expressions will involve the distribution of this fraction of investors who obtain good evaluations for a bad firm. Clearly, this adds unnecessary computational complexity to the model without generating any commensurate economic insights, and we have therefore adopted the correlated information structure above.

products and its management for a long time. Third, the size of c may depend upon a firm's industry membership: the projects of firms belonging to certain industries may be intrinsically more complex and therefore difficult to evaluate than those of firms in other industries. Finally, for a given industry, and in a given equity market, investors may differ in their evaluation costs. For example, a technology analyst working for a major U.S investment bank may have a lower cost of evaluating a French software company compared to most ordinary investors in the U.S, and possibly compared to many ordinary French investors as well.[13]

To capture the above ideas, we assume that, in each market, there are two kinds of investors: those with a high cost $c = c_h$ of evaluating the firm ("high-cost investors"), and those with a low evaluation cost, $c = c_\ell$ ("low-cost investors"). Of the N potential investors in the firm's equity offering, a number N_ℓ are low cost investors, while the remaining number N_h are high cost investors, $N = N_\ell + N_h$. In order to capture the notion that investors in different exchanges may have different levels of sophistication in valuing a firm, we allow the numbers N_ℓ, and N_h to differ across exchanges (we will superscript these numbers with X and Y as required when we allow these to differ across exchanges). We will often refer to the number of low-cost investors in a given exchange as its "low-cost investor-base."

When faced with a firm making an equity offering in a given exchange, investors (traders) in that exchange can do one of three things, after observing the price per share set by the firm, and the number of shares offered: Ignore the IPO altogether and invest in the risk-free asset; engage in uninformed bidding for shares in the IPO; or conduct a costly evaluation of the firm, and depending on the outcome of this evaluation, bid (if he gets a good evaluation) or not bid (if he gets a bad evaluation) for a share.[14] Among these alternatives, each investor chooses the one maximizing the expected value of time 1 cash flow.[15] We assume that each investor bids for only one share, regardless of whether he engages in informed or uninformed

[13]Note that a particular investor may be a low-cost information producer when trading in one market (say, the Nasdaq), but may be a high-cost information producer when trading in another (e.g., the Milan Stock Exchange) due to a variety of reasons (e.g., the lack of familiarity with language and accounting conventions related to the latter market).

[14]Clearly, it is never optimal for any investor to produce information, and then choose to bid for a share in the IPO even after getting a bad evaluation (since, for any investor to produce information, the information produced must yield him some benefit in terms of discriminating between type G and type B firms).

[15]We assume that any amount of an investor's wealth not invested in the firm's equity, or devoted to evaluating the firm, is invested in the risk-free asset.

bidding.[16]

The proportion of those high-cost and low-cost investors participating in the equity offering who choose to become informed about the firm, denoted by α_h and α_ℓ respectively, is determined as follows. After observing the price and number of shares offered by the firm in the IPO, each investor chooses between not participating in the IPO at all, and participating as an informed investor, with a probability α_i, $i \in \{h, \ell\}$. In other words, if an investor decides to participate in the IPO, he conducts a costly evaluation of the firm with a probability α_i (and follow the optimal bidding strategy depending on its outcome), and makes an uninformed bid for a share in the IPO with the complementary probability $(1 - \alpha_i)$. The probability α_i thus measures the extent of information production among each category of participating investor in the equity offering: in equilibrium, a fraction α_i of the participants in the IPO produce information, while the remaining fraction $(1 - \alpha_i)$ bid uninformed (investors will be indifferent between producing and not producing information in equilibrium).[17] The fraction of high cost and low cost investors in any market adopting these strategies will depend on the price set by the firm in the equity offering, the investors' prior probability assessment about the firm's true value, and the cost and precision of the evaluation technology available to each kind of investor. Further, when the firm has a choice of exchanges to list equity, the particular exchange where the firm is listed, and the listing standards of the exchange where the firm has listed its equity may also convey information to investors, and thus affect investor strategies (and consequently, the pricing of equity).

2.3 The Exchange's Listing Procedure

When approached by any firm for listing, the exchange conducts an investigation of the firm, requiring them to provide various pieces of information, and also requesting the firm to recast its financial

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[16]None of our results are driven by the assumption of each investor buying only one share, made for modeling simplicity. It can be generalized to the case where each investor can buy multiple shares, and also to the case where different investors may buy different numbers of shares. Allowing these cases simply complicates the model without generating commensurate insights.

[17]Since, in equilibrium, each investor will be indifferent between informed and uninformed bidding in the IPO, and information-production costs are identical *within* a given cost-group (i.e., high-cost or low-cost), the exact identity of those who produce information within the group and those who engage in uninformed bidding is irrelevant here. Formally, we assume that investors follow a randomized strategy, with a fraction α choosing to produce information, and the remaining fraction $(1 - \alpha)$ choosing to bid uniformed in the IPO, based on the outcome of a collectively observed randomization device. This way of modeling the investors' choice between informed and uninformed bidding, where investors choose to produce information with a certain probability (rather than confining them to pure strategies) seems to be the most elegant modeling approach here, since it yields a symmetric equilibrium (where identical agents make identical choices). An alternative modeling approach, involving only pure strategies, would measure the extent of information production in the new issues market by the number of investors producing information in equilibrium (Chemmanur (1993) uses this alternative approach in a model of IPO underpricing). However, this alternative approach would require that some members of an otherwise identical cohort of investors choose to produce information, while others do not, so that the equilibrium would be asymmetric. See also Milgrom (1982), who uses both of these approaches to model auctions with information production, and demonstrates the essential equivalence of these alternative approaches.

statements and other disclosures in the format prescribed by the exchange. The rigor of the investigation of the firm performed by the exchange prior to listing, and the accessibility to investors of the information contained in the various financial statements provided by the firm subsequent to listing (i.e, the "transparency" of the firm's disclosures) depends on the "listing standards" set by the exchange. Typically, as an exchange's listing standard grows more stringent, only a smaller fraction of the firms applying for listing at that exchange are accepted, and perhaps even more important, the financial disclosures made by firms listed at that exchange are more transparent (in the sense that, not only is more information available to outsiders, but the available information becomes more credible because of the more-stringent policing of firm disclosures by the exchange). To capture these ideas, we model the exchange's listing procedure in the following manner.

At any time t, each exchange chooses a "listing standard" q_t, which affects both the probability of the firm being accepted for listing on the exchange, and also the "transparency" of the financial statements made by the firm after listing. The probability of a firm being listed is given by:

$$\mathbf{Pr\{accepted \mid f = G\} = 1, \quad Pr\{accepted \mid f = B\} = 1 - q_t.} \tag{3}$$

Thus, the higher the listing standard q_t, the better the average quality of firms listed on the exchange, with $q_t \in [0, \bar{q}]$. Further, we capture the notion of greater transparency of financial statements made by firms listed on an exchange with higher listing standards by assuming that the precision of the outside investors evaluation, γ_t, is a strictly increasing function of the exchange's listing standard q_t: i.e., $\gamma_t = \gamma(q_t)$.[18] To begin with, we will assume that the exchange's listing standard q is exogenous (we suppress the time subscript t when it is not required for clarity of exposition); in later sections, we will endogenize the exchange's choice of this listing standard. We further assume that, if rejected by both exchanges X and Y, a firm may delay its IPO or raise capital from other sources, both of which are less advantageous to the entrepreneur (i.e., the entrepreneur will prefer to raise capital from getting listed and conducting an equity offering on any one of

[18]Notice that, there are two effects to an exchange setting a higher listing standard in our model. First, it will accept only a lower proportion of the firms approaching it for a listing. Second, it will investigate firms applying for listing and enforce regulations (e.g., regarding the form and truthfulness of disclosures) with a greater degree of stringency (e.g., by de-listing firms which are found to have violated various rules governing these with an greater probability), so that more reliable information is available to outsiders attempting to evaluate the firm, thus increasing the precision of their evaluation of the firm ("transparency" in our model). While these two aspects of a higher listing standard set by the exchange go together, they become important in driving results at different points in the paper.

the two exchanges X or Y to these other alternatives if they will allow listing of the firm).[19]

Finally, the cost to the firm of obtaining a listing on any exchange consists of two components: The actual listing fee of the exchange and the costs associated with complying with the exchange's transparency requirements (which may, in fact, be the larger component in many cases). For simplicity, we will lump both these items together and refer to it as the listing cost, denoted by F. We will allow these listing costs to vary across exchanges (we will use the superscripts X and Y to denote the fees on the two exchanges when required).[20] In general, one would expect the listing costs to be greater for exchanges with higher listing standards (partly because of the greater magnitude of the compliance cost component), though we will *not* assume this to be the case always.

3. Equilibrium with Listing in Only One Market

In this section, we assume that each firm is allowed to list its equity only in the domestic market. This allows us to examine the details of the equilibrium in a given equity market, without the additional complication of exchange choice, which will be introduced in the next section.

Definition of equilibrium. The equilibrium concept we use is that of Efficient Perfect Bayesian Equilibrium.[21] An equilibrium consists of (i) a choice of share price by the entrepreneur making the equity offering, along with the choice of the number of shares to be offered to outsiders, and the choice of the exchange (possibly dual listing) to list equity (ii) a choice by the exchange about whether to allow a firm to list its equity (and in section 5 onwards, a choice of listing standard as well); and (iii) a decision by each investor about whether or not to participate in the IPO, and if the decision is to participate, a choice by each investor about the probability of his producing information. Each of the above choices must be such that: (a) The choices of each

[19]This assumption is appropriate, given that the objective of this paper is neither the choice of a firm between public versus private equity financing, nor the optimal timing of a firm's going public decision. For a model addressing these issues, see Chemmanur and Fulghieri (1999).

[20]In practice, both of these components of the listing cost seem to vary significantly across exchanges. For example, comparing the costs of a foreign company to obtain a listing on the NYSE versus the London Stock Exchange (LSE), it has been documented (see, e.g., Fanto and Karmel, 1997) that both the direct listing costs and the indirect reporting and compliance costs are significantly greater for the NYSE than for the LSE. While the indirect costs of listing on the NYSE are greater because of having to meet the much more stringent SEC requirements, the directing costs of listing on the NYSE are $100,000 initial listing fees (and annual fees ranging from $16,000 to $30,000), versus an initial listing fee of only $6,000 on the LSE (with a $3000 annual fee).

[21]Thus, we look for the Perfect Bayesian Equilibrium (see Fudenberg and Tirole (1991)) involving the least amount of dissipative costs. In later sections, we will characterize the equilibrium while allowing for the firm to choose the exchange on which to list equity. Further, from section 6 onwards, we will make use of a dynamic model where the listing standard of the exchange is endogenous. However, the general definition of equilibrium used in these sections will be the same as the one described here.

party maximizes their objective, given the equilibrium beliefs and choices of others; (b) The beliefs of all parties are consistent with the equilibrium choices of others; further, along the equilibrium path, these beliefs are formed using Bayes' rule. (c) Any deviation from his equilibrium strategy by any party is met by beliefs by other parties which yield the deviating party a lower expected payoff compared to that obtained in equilibrium.

In proposition 1, we characterize the basic structure of an equilibrium with information production. We discuss the nature of this equilibrium at some length, since we build on this basic equilibrium in subsequent sections of the paper.[22]

Proposition 1 (Equilibrium without Exchange Choice). *When a firm is allowed to list on only one exchange, an equilibrium with information production involves the following:*

The type G firm: It issues n_H shares, each at a price p_H, raising a total amount I for investment.

The type B firm: With probability β, $0 < \beta \leq 1$, it pools with the type G firm by issuing n_H shares at the price p_H, of which only a number $\lambda\, n_H$ are bought by investors in equilibrium ($0 < \lambda < 1$), thus raising only an amount λI; with probability $(1 - \beta)$, it separates from the type G firm, by issuing n_L shares at a lower price p_L ($n_L > n_H$, $p_L < p_H$), thus raising the entire amount I required for investment.

Investors: (i) If $N_\ell \geq \bar{N}_\ell$ (defined in the appendix), then low cost investors are the marginal information producers in equilibrium. In this, a fraction δ_ℓ participate in the IPO, of which α_ℓ of these investors produce information, while the remaining fraction $(1 - \alpha_\ell)$ bid uninformed. A fraction δ_h of high-cost investors participate in the equity offering as uninformed bidders (i.e., none produce information).

(ii) If $N_\ell < \bar{N}_\ell$ (defined in the appendix), then high-cost investors are the marginal information producers. Then, all low-cost investors participate in the equity offering as information producers ($\delta_\ell = 1$, and $\alpha_\ell = 1$). A fraction δ_h of the high-cost investors participate in the equity offering, of which a fraction α_h produce

[22]Throughout this paper, our focus will be on partially pooling equilibria, where the two types of firms pool (with some probability) by making similar decisions about equity pricing, number of shares to offer, and listing, so that there is some need for costly information production by investors. Thus, we will not focus on equilibria where (a) the information technology is so costly or noisy that there is no incentive for any investor to evaluate firms equilibrium, and the equilibrium is fully pooling; or (b) the actions taken by the two types of firms are different in equilibrium, so that the equilibrium is fully separating, thus eliminating any need for costly information production by outsiders. The first set of equilibria of the category (a) are clearly uninteresting, in the sense that they arise only when information of any significant precision is unavailable to outsiders at a reasonable cost, so that the issues of interest to us in this paper do not arise at all (the parametric restrictions on c and γ under which the equilibrium is of this nature is available to interested readers from the authors). The second category (b) of equilibria would perhaps have some intrinsic interest, but can be shown not to exist in our setting.

information, while the remaining fraction (1 - α_h) engage in uninformed bidding for a share of stock.[23] *This equilibrium will always exist if the outsiders' evaluation cost is not too high, so that $c < c_s$.*

In equilibrium, the type G firm always sets the high price p_H, since it is confident that it will always be able to raise the full amount I required for investment (since all investors who conduct an evaluation of the firm obtain a good evaluation for a type G firm). The number of shares offered for sale is given by:

$$p_H n_H = I. \tag{4}$$

The type B firm, on the other hand, has to pay a price if it mimics the type G firm by setting the price p_H, and number of shares offered, n_H. Among informed investors, only a fraction $(1 - \gamma)$ get a good evaluation for the firm, while the remaining fraction γ get a bad evaluation and do not bid for shares. This means that, of the n_H shares offered by type B firm, some may go unsold, thus leading the firm to scale back the investment in its positive net present value project (wasting value). We denote by λ the fraction of shares offered that are sold by a type B firm if it mimics, and by $\hat{n}_H^*$, the number of shares sold in this case ($\hat{n}_H^* = \lambda n_H$).

In contrast, if the type B firm separates by setting a different (low) price p_L, it is revealed as the type B firm, but is able to sell as many shares it would like, since the price would then be the true (full information) price. It is thus able to raise the full investment amount I, thus avoiding any scaling back in investment. This separating price p_L, and the corresponding number of shares issued, n_L, then satisfy:

$$p_L = \frac{1}{m + n_L} V_B; \quad p_L n_L = I. \tag{5}$$

We will see later that, in equilibrium, the type B firm will be indifferent between mimicking the type G, and separating by setting a different price-share combination; it will mimic the type G with a certain probability β, while separating with the remaining probability $(1 - \beta)$.

Denote by θ the probability assessed by an uninformed investor that a firm offering n_H shares at a price p_H per share is a type G firm (taking into account the type B firm's equilibrium strategy of pooling with the type G firm with a probability β). Using Bayes' rule, this is given by:

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[23]The out-of-equilibrium beliefs supporting the above equilibrium are that outsiders infer that any firm setting a price other than p_H or p_L, or offering a number of shares other than n_H (at the price p_H) or n_L (at the price p_L) is a type B firm with probability 1.

$$\theta \equiv \text{Prob}\{f = G \mid p = p_H, n = n_H\} = \frac{\omega}{\omega + \beta(1-\omega)}. \tag{6}$$

Further, for any investor (high-cost or low-cost) to participate in the equity offering as an uninformed bidder, the following weak inequality has to be satisfied:

$$p_H \leq \theta \frac{V_G}{m + n_H} + (1-\theta)\frac{\lambda V_B}{m + \lambda n_H}. \tag{7}$$

Thus, an uninformed investor must be able to recoup the price paid (in terms of expected value).

It now remains to discuss how the fraction of investors producing information, and the probability β of the type B firm pooling with the type G firm, are determined in equilibrium. For concreteness, we will discuss this in the context of the equilibrium where the low cost investors are the marginal information producers. For any low-cost participant in the equity offering to have an incentive to incur the additional cost c_ℓ of producing information, the cost of producing information must be less than or equal to the expected value of the benefit from doing so (which arises from the ability to avoid bidding for a share in a bad firm if the informed investor gets a bad evaluation). Thus, any equilibrium with information production (where low-cost investors are the marginal information producers) will satisfy:

$$c_\ell \leq \gamma(1-\theta)\left[p_H - \frac{\lambda}{m + \lambda n_H} V_B\right], \quad \text{and} \tag{8}$$

$$c_h > \gamma(1-\theta)\left[p_H - \frac{\lambda}{m + \lambda n_H} V_B\right]. \tag{9}$$

Notice that (9) holds by definition, since low-cost investors are the marginal information producers in this equilibrium (so that $\alpha_h = 0$, by definition).

Now, to see how the fraction of information producers, α_ℓ, is determined in this equilibrium, consider first the extreme case where most investors engage in uninformed bidding. In this case, the cost imposed on the type B firm (in terms of having to scale back its investment) is very low, so that it has an

incentive to mimic the type G firm by setting the high price p_H very often (thus creating an incentive for more low-cost investors to produce information). At the other extreme, if most low-cost investors in the IPO market choose to become informed, the cost to the type B firm from pooling with the type G firm will then be very high, so that it rarely mimics the type G (thus creating an incentive for more investors to remain uninformed). Thus, the equilibrium α_ℓ will be such that the type B firm is indifferent between selling $\lambda\, n_H$ shares at price p_H, and selling n_L shares at price p_L. In other words, in equilibrium, the type B entrepreneur is indifferent between owning a smaller fraction of the larger firm with expected time 1 cash flow V_B (which will result if it sells n_L shares at price p_L), and a larger fraction of the smaller firm with expected time 1 cash flow $\lambda\, V_B$ (which will result if its sells $\lambda\, n_H$ shares at a price p_H). Thus, (10) will hold in equilibrium:

$$\frac{m}{m + n_L} V_B = \frac{m}{m + \lambda n_H} \lambda V_B. \qquad (10)$$

At the same time, β, the probability with which the type B firm sets the high price p_H, is determined such that each low-cost equity offering participant is indifferent between producing and not producing information. To see the relationship between the equilibrium values of β and α_ℓ, consider first the extreme case where β is close to 1. In this case, since the type B firm mimics the type G most of the time, the expected benefit to low-cost investors from producing information is very high, thereby creating an incentive for a large fraction of these investors to produce information (thus imposing a high penalty on the type B firm for mimicking the type G, and inducing it to reduce the probability β). At the other extreme, if β is close to zero (implying that the type B firm almost never mimics the type G), there is almost no benefit to outsiders from producing information, thus driving down the fraction of low-cost participants who produce information (thereby reducing the cost imposed on the type B firm if it mimics the type G, and inducing it to increase the probability β). Therefore, the equilibrium value of β will be such that all investors are indifferent between producing and not producing information, so that (8) hold as an equality in equilibrium. In summary, the values of α_ℓ, β, and λ are determined simultaneously in equilibrium, such that (7), (8), and (10) hold as equalities.

It now remains to mention how the fraction of investors of each kind participating in the equity offering is determined. Recall that, when uninformed, low-cost and high-cost investors are identical (since

the only difference between them is in their information production cost). Assuming therefore, for ease of exposition that any shares not taken by informed low-cost investors are first bought by uninformed low-cost investors and then by uninformed high-cost investors (i.e., $\delta_h = 0$ if $\delta_\ell < 1$), δ_ℓ and δ_h are uniquely determined from:

$$n_H = \delta_\ell N_\ell + \delta_h N_h, \quad \hat{n}_H = (1 - \gamma\alpha_\ell)\delta_\ell N_\ell + \delta_h N_h . \tag{11}$$

Notice that (11) reflects the fact that type G firms are able to sell equity to all information producers, while type B firms sell only to uninformed investors (of both kinds, if need be) and to low-cost information producers who (erroneously) get a good evaluation. In summary, an equilibrium consists of a collection of variables $\{n_H^*, \hat{n}_H^*, \theta^*, \beta^*, p_H^*, \alpha_\ell^*, \alpha_h^*, \delta_\ell^*, \delta_h^*, \lambda^*, p_L^*, n_L^*\}$ such that the system of equations (4) to (11) is satisfied.

We now discuss how the equilibrium where the high-cost investors are the marginal information producers differs from the above equilibrium. By analogy with (8), we know that, in this case, the high-cost investor's information production cost must satisfy:

$$c_h \le \gamma(1 - \theta)\left[p_H - \frac{\lambda}{m + \lambda n_H} V_B\right], \tag{12}$$

since the cost of producing information should be less than or equal to its benefit for a high cost investor. Further, since $c_\ell < c_h$, in this equilibrium c_ℓ satisfies:

$$c_\ell < \gamma(1 - \theta)\left[p_H - \frac{\lambda}{m + \lambda n_H} V_B\right]. \tag{13}$$

Since (13) implies that low-cost investors make a positive expected profit from information production, all low-cost investors will participate in the equity offering (and will engage in informed bidding), so that $\alpha_\ell = \delta_\ell = 1$. The fraction δ_h of high-cost investors participating in the offering is given by:

$$n_H = N_\ell + \delta_h N_h, \quad \hat{n}_H = (1 - \gamma)N_\ell + (1 - \alpha_h\gamma)\delta_h N_h , \tag{14}$$

where (14) reflects the fact that the type B firm now sells equity to uninformed high-cost investors, informed high-cost investors who erroneously get a good evaluation, and informed low-cost investors who get a good

evaluation (all low-cost are informed in this case). In summary, an equilibrium where high-cost investors are the marginal information producers consists of a collection of variables $\{n_H^*, \hat{n}_H^*, \theta^*, \beta^*, p_H^*, \alpha_\ell^*, \alpha_h^*, \delta_\ell^*, \delta_h^*, \lambda^*, p_L^*, n_L^*\}$ such that the system of equations (4) to (7), (10), and (12) to (14) are satisfied.

It is important to note that, in this partially pooling equilibrium where the high-cost investors are marginal, either type firm pays a larger cost per share sold to informed investors (since investors' information production costs are borne in equilibrium by the firm through a lower share price) compared to the case where the low-cost investors are the marginal information producers. When the firm is constrained to list only on the domestic exchange, it has no control over the kind of equilibrium that prevails. This however, changes when the firm has a choice of exchange on which to list its equity. Finally, it is also important to note that, in any given kind of equilibrium (i.e, regardless of whether it is the high-cost or the low-cost investors who are the marginal information producers), the price p_H increases as the transparency γ of the exchange goes up. Intuitively, this occurs because the type B firm mimics the type G less often as the transparency γ of the exchange increases.[24]

4. Equilibrium with Exchange Choice

We now allow for the firm to choose between the domestic exchange X and the foreign exchange Y. We continue to assume in this section that listing on both the exchanges X and Y simultaneously (dual listing) is not allowed (we introduce dual listing in the next section). Without loss of generality we assume that the listing standard set by the foreign exchange Y is higher than that set by the domestic exchange: i.e., $q^Y > q^X$. This, in turn, implies that $\gamma^Y > \gamma^X$, i.e., the transparency of the foreign exchange is better than that of the domestic exchange.[25] Since listing on only one exchange at a time is allowed in this section, the nature of the equilibrium remains essentially the same here as in the previous section, except that, in addition to the other choices discussed in the last section, the firm has to make the choice of exchange to list equity in equilibrium. Given the symmetry between the two exchanges, we will continue to use similar notation as in the previous

[24]The two results noted in this paragraph are proved in the appendix.

[25]Since the focus in sections 4 and 5 on a firm's choice of exchange to list on, and firms are directly concerned about the transparency of the exchange, we describe all propositions developed in these sections in terms of the transparency γ of an exchange rather than in terms of the listing standard q. However, the reader should keep in mind that all restrictions on γ can be directly translated into restrictions on the listing standard q, since the listing standard and the transparency of that exchange are one-to-one functions of each other. From section 6 onwards, where we endogenize the exchanges' choice of listing standards, we shift our focus to exchanges' choice of listing standards, and will therefore describe various propositions in terms of q.

section, with the superscripts X and Y attached to various variables, as required, to distinguish between the values of these variables for exchanges X and Y respectively. Propositions 2 and 3 study the effect of exchange transparency and the size of exchanges' low-cost investor base on firm's exchange choice.

Proposition 2 (Exchange Choice with a Larger Low-Cost Investor Base in the Foreign Exchange). *Let the listing fee of both exchanges be the same ($F^X = F^Y$). Then, if $N_\ell^Y \geq N_\ell^X$, the firm lists on exchange Y.*

Proposition 2 deals with the less complicated case where the more transparent exchange, Y, also has a larger low-cost investor base. In this case, there are two possibilities: (i) The low-cost investors are the marginal investors if the firm chooses to get listed and issue equity in either exchange; (ii) The high-cost investors are the marginal information producers if the firm chooses to get listed and issue equity in either exchange; (iii) The low-cost are marginal if the firm chooses exchange Y, and the high-cost are marginal if the firm chooses X. In all three of these cases, the firm is better off listing on exchange Y, since the equilibrium price per share will be greater when exchange Y is chosen. The assumption that the listing fees are the same across exchanges ensures that this fee is not a consideration in the listing decision.

Proposition 3 (Exchange Choice with a Larger Low-Cost Investor Base in the Domestic Exchange). *Let the listing fee of both exchanges be the same ($F^X = F^Y$), and $N_\ell^Y < N_\ell^X$. Then the firm lists on exchange X if $N_\ell^X \geq \bar{N}_\ell^X$, $N_\ell^Y < \bar{N}_\ell^Y$, and $\gamma^Y < \bar{\gamma}^Y$ (defined in the appendix). It lists on exchange Y otherwise.*

When the domestic exchange X has the advantage of having a larger base of low-cost investors, the exchange choice is determined by the trade-off between the greater transparency (provided by the foreign exchange) and the desire of the firm to obtain an equilibrium where low-cost investors are marginal. Thus, if the proportion of low-cost information producers in the foreign exchange is not large enough, so that a listing on that exchange will result in an equilibrium where the high-cost investors are the marginal information producers, then the firm prefers to be listed on the (less transparent) domestic exchange X if this results in the more desirable equilibrium where the low-cost are the marginal information producers. On the other hand, the firm continues to prefer the foreign exchange if its superiority in transparency is sufficiently large that it overcomes the disadvantage of an equilibrium where high-cost investors are the marginal information producers. Further, even without such an advantage in transparency, firms may prefer to list on the foreign exchange if the number of low-cost investors in that exchange, while smaller than that in the domestic exchange, is nevertheless large enough to ensure an equilibrium in which low-cost investors are the

marginal information producers (as in the case where $N_\ell^Y \geq \bar{N}_\ell^Y$). Finally, if the proportion of low-cost investors even in the domestic exchange is so low that the equilibrium even with a listing in the domestic exchange will be one where the high-cost are the marginal information producers, then the firm again chooses to list on the foreign exchange, since the better transparency of that exchange makes it the preferred exchange.

Proposition 4 (Exchange Choice with Different Listing Costs). *Let $F^Y > F^X$. Then the firm chooses to list in the domestic exchange if $\gamma^Y < \bar{\gamma}^Y$, and in the foreign exchange otherwise.*

This proposition introduces the third ingredient affecting a firm's choice of exchange in our model, namely, the costs involved in listing on each exchange (which is the sum of the listing fee charged by the exchange, and the compliance costs incurred by the firm). The proposition shows that the additional transparency afforded by the higher listing standards of the foreign exchange has to be large enough, to be worth the greater listing costs, and the potential switch in the equilibrium to one where low-cost investors are the marginal information producers.

5. Equilibrium with Dual Listing

In this section, we introduce the possibility of dual listing. Thus, the firm can ask for listing on exchange X alone; exchange Y alone, or both (dual-listing). Dual listing has two effects in this setting. First, it widens the base of investors who have a comparative advantage in valuing the firm, namely, the low-cost information producers. Thus, upon dual-listing, the number of low-cost investors becomes $N_\ell = N_\ell^X + N_\ell^Y$, and the number of high-cost investors becomes $N_h = N_h^X + N_h^Y$. Perhaps the more interesting effect of dual-listing, however, is on precision: the precision of the information available to investors in *both* exchanges goes up (since the additional regulations on disclosure imposed by the exchange with the more stringent listing standards would help the investors trading even in the exchange with the lower listing standards access better quality information when valuing the firm). Thus, the precision of information available (transparency) available to investors trading on both exchanges is γ^Y in the case of dual listing (we continue to maintain the assumption that $\gamma^Y > \gamma^X$ in this section).

Dual listing therefore confers advantages on the firm, in terms of both investor-base and transparency. However, this has to be traded off against the significant additional listing costs that has to be borne by the firm (not only the additional listing fees charged by the second exchange, but also the compliance costs associated with the additional regulation of financial disclosures arising from listing on a second exchange).

We now examine the conditions under which dual listing is worthwhile in equilibrium.

Proposition 5 (Dual Listing with a Larger Low-Cost Investor Base in the Foreign Exchange)*. Let* $F^X = F^Y = F$ *(defined in the appendix), and* $N_\ell^Y \geq N_\ell^X$*, so that listing on exchange Y alone dominates listing on exchange X alone. Then the firm will dual-list if* $N_\ell^X + N_\ell^Y$ *is greater than or equal to a certain value* $\bar{N}_\ell^D$*,* $F < \bar{F}$*, and* $N_\ell^Y < \bar{N}_\ell^Y$*. Otherwise the firm lists on exchange Y alone.*

The above proposition addresses the simpler case where the foreign exchange Y has both greater transparency than the domestic exchange and also has a larger low-cost investor-base (so that, if dual listing were not possible, the firm always prefers to list on the foreign exchange Y rather than on the domestic exchange X alone). In this case, dual listing enlarges the firm's low-cost investor-base, but has no effect on precision, since, in any case, the firm would have listed on the more transparent exchange Y in the absence of dual listing). In this case, there are two possibilities. If listing on the foreign exchange Y alone leads to an equilibrium where the low-cost investors are the marginal information producers, then the firm simply lists on Y alone, since there is no additional benefit from dual listing in this case (while there are additional costs). If, however, listing on the foreign exchange Y alone leads to an equilibrium where the high-cost investors are the marginal information producers, then there are additional benefits to be gained (in terms of widening the low-cost investor base), though there are also additional listing costs. In this case, the firm chooses dual listing if listing on the domestic exchange in addition to the foreign exchange widens the investor base to the such an extent that it allows the equilibrium to switch to one where it is the low-cost investors who are the marginal information producers, and further, the costs involved in listing on the additional exchange are not so large that they swamp these additional benefits. The firm continues to be listed on the foreign exchange alone if the addition to investor base from dual listing is not significant enough to switch to an equilibrium where low-cost investors are the marginal information producers, or, alternatively, the additional listing costs are so large that the switch to such an equilibrium is not worthwhile.

Proposition 6 (Dual Listing with a Larger Low-Cost Investor Base in the Domestic Exchange) *Let* $F^X = F^Y = F$*, and* $N_\ell^X > N_\ell^Y$*. If, in addition:*

(i) $N_\ell^Y \geq \bar{N}_\ell^Y$*, then the firm lists on exchange Y alone in equilibrium.*

(ii) $N_\ell^Y < \bar{N}_\ell^Y$*, and* $N_\ell^X < \bar{N}_\ell^X$*, the firm dual-lists if* $N_\ell^X + N_\ell^Y \geq \bar{N}_\ell^D$ *(defined in the appendix) and* $F \leq \bar{F}$*; it lists on exchange Y alone otherwise.*

(iii) $N_\ell^Y < \bar{N}_\ell^Y$ *but* $N_\ell^X \geq \bar{N}_\ell^X$*, and further:*

(a) $F < F(\gamma^Y)$ *(defined in the appendix), the firm dual-lists.*

(b) $F > F(\gamma^Y)$*, then the firm lists on only one exchange, with the listing occurring on exchange X if* $\gamma^Y < \hat{\gamma}$*, and on exchange Y if* $\gamma^Y \leq \hat{\gamma}$*.*

When the domestic exchange X has the advantage of having a larger low-cost investor base over the foreign exchange, dual listing can have two effects: It may increase the precision of information available to investors, and enlarge the low-cost investor-base of the firm (in comparison to the case where dual lists on only one exchange). Case (i) involves the situation where, even though the foreign exchange has only a smaller pool of low-cost investors, this pool is large enough that the low-cost are the marginal information producers in equilibrium; the firm then lists on exchange Y alone (since this is the more transparent exchange, and there is no additional benefit to be gained from dual listing, yet additional costs to be incurred). Case (ii) deals with the more interesting case where neither the domestic exchange X nor the foreign exchange Y has a pool of low-cost investors large enough that an equilibrium with low-cost investors will not arise from listing in either exchange X alone or Y alone. In this case, dual listing increases the investor base, while the transparency of trading will be that of the exchange with the higher listing standard, Y. Dual listing will be equilibrium choice if the enlarged investor base switches the equilibrium to one where the low-cost investors are the marginal information producers, provided that the additional listing cost to be incurred is not so high that the benefit from dual listing is overcome. However, if the low-cost investor pool is not large-enough even after dual listing for such a switch to a low-cost information-producer-equilibrium to occur, then the firm chooses to be listed on exchange Y alone, taking advantage of its higher listing standards (and therefore transparency).

Finally, case (iii) studies the situation where, while the foreign exchange has only a small base of low-cost investors, the domestic exchange has a pool of such investors large enough that the equilibrium that would arise from listing in the domestic exchange alone would be one with the low-cost investors being the marginal information producers. Here the difference in listing standards between the two exchanges, as well as the cost of listing on an additional exchange become important. In this case, the firm dual-lists if the costs of listing on the additional exchange are not too large, so that the benefit from the increased transparency attained by dual-listing is larger than these additional listing costs ((iii.a)). The firm lists only on one exchange

if the magnitude of the listing costs exceeds a certain threshold value F̃. The domestic exchange X is chosen as the only exchange to list in this case (iii.b) if the superiority in transparency of the foreign exchange is not too large, while the foreign exchange is chosen if this superiority exceeds a certain threshold level.

6. Exchange Reputation and Listing Standard Choice

In this section and the remainder of the paper, we build upon the single-period model discussed so far to develop a dynamic model (two periods, three dates: 0, 1 and 2) to endogenize an exchange's choice of listing standard. We assume in this section that the exchange acts as a monopolist, setting standards to maximize the present value of its cash flows in isolation. In the next section, we will introduce competition between two exchanges, with each exchange endogenously choosing its listing standards taking into account the listing standard choice of the other exchange, in addition to the impact of the listing standard choice on its own reputation. We will also endogenize the listing fees charged by each exchange in this section.

In the dynamic model, at each date (time 0 and time 1) a new round of firms enter the equity market, and apply for listing to the exchange. Before the firms' entry, the exchange decides on its listing standard for applicant firms. The cash flows of firms who are listed at time 0 are realized at time 1, while that of those listed at time 1 are realized at time 2, at which point the game ends (see figure 1). The remaining events occurring at each date are the same as in the basic (single-period) model: thus, the dynamic model differs from the basic model only in that the exchange's choice of listing standard is endogenous, and in that two rounds of firms (single-period players) apply for listing to the exchange, which is a long-term (two-period) player.

The exchange's listing procedure continues to be as discussed in section 2.3, with the exchange's listing standard q_t, determining both the fraction of firms that are listed (given by (3)), and also the precision of the information available to information producers (transparency of the exchange), given by $\gamma_t = \gamma_t(q_t)$. However, here we simplify the $\gamma_t(.)$ function further by assuming the specific functional form, $\gamma_t(q_t) = q_t$.[26] Further, we assume in this section that listing costs of each firm at a given exchange consist solely of listing fees so that the entire amount F expended by firms in listing costs goes to the exchange as listing fees (in other

[26]Clearly, one can incorporate many different forms for the $\gamma_t(.)$ function without changing the essential nature of our results. More complicated functional forms, while making various expressions much more complicated, do not add any significant insights.

words, we ignore any dissipative compliance costs incurred by firms).[27]

We now assume that, at each date, exchanges chooses their listing standard privately. In order to model the notion of "reputation" for an exchange, we introduce two types of exchanges: while most exchanges are "Value Maximizing" (or type M), a small proportion are "Standard Maximizing" (or type S) exchanges. The objective of a value maximizing exchange M is to set its listing standards to maximize the present value of its cash flows from future listing fees.[28] The standard maximizing exchange S, on the other hand, simply sets the highest possible standard, $\bar{q}$ at each date t = 0, 1. While each exchange knows its own type, at any date t outsiders (firms and investors) observe only a prior probability $\rho_t = 0, 1$ of an exchange being of type S.

Clearly, the value maximizing exchange is subject to moral hazard, which arises from two sources. First, if it sets higher standards for allowing firms to list, it may have to incur greater verification and regulatory costs to verify and regulate the disclosures made by these firms. We denote such verification costs by $w_t(q_t^E)$, and assume that this cost is greater as an exchange's listing standard is greater (in the limit, such verification costs will clearly be zero if an exchange admits all firms that apply, and does not expend any resources to regulate these firms' disclosures). Second, by raising the listing standard, the exchange reduces its expected cash flow from listing fees, since a smaller fraction of firms applying for listing are accepted. Thus, our definition of a type S exchange is simply that of an "idealized" exchange, which is not subject to this pressure to lower the listing standard in order to maximize revenue.

Given that standard maximizing exchanges set the highest possible listing standard $\bar{q}$ at each date, the probability ρ_0 of an exchange being of type S is a measure of its "reputation" at time 0 for setting stringent listing standards.[29] At time 1, outsiders update this probability based on additional information they observe prior to this date to compute ρ_1, the time 1 reputation of each exchange. Normalizing the number of firms applying for listing on each exchange at each date to equal 1, this information consists of whether the firm

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[27]This is essentially an assumption that the compliance costs are the same across exchanges, so that such costs can be normalized to equal zero. We make this assumption for ease of exposition, since we do not intend to study the effects of differential compliance costs here. However, such differences in firms' compliance costs across exchanges can be re-introduced easily, at the expense of some additional notation.

[28]One might argue that, in practice, not all exchanges are completely value maximizing, being owned by members in some cases. It is, however, true that considerations of value maximization enter into the decision making in most exchanges, especially in light of the fact that many exchanges have recently gone public (e.g., the LSE and the Australian Stock Exchange), or are in the process of doing so.

[29]The assumption of a small proportion of agents not subject to moral hazard has now become the standard way of modelling reputation in finite horizon games (see, e.g., Kreps and Wilson (1982a) or, in a finance setting, Chemmanur and Fulghieri (1994)).

listed by the exchange at time 0 turned out to be type B or type G (inferred from its true cash flows, realized and publicly observed prior to time 1); or whether any firm was listed by the exchange at all at time 0.[30]

The expected volume Q_t of firms listed at date t at an exchange with listing standards q_t is given by:

$$Q_t = \omega + (1 - q_t)(1 - \omega). \tag{15}$$

Assuming that the exchange charges a constant fraction k, $0 < k < 1$, of firm value, the listing fee F_t collected by the exchange at date t is given by:[31]

$$F_t = k V_{Ht} = k(m + n_{Ht})p_{Ht}\ , \tag{16}$$

where V_{Ht} is the total equity value of a firm whose equity was sold at date t, t= 0, 1, at the share price p_{Ht}.

Given that the type S exchange always sets the highest possible listing standard at any date t, all outsiders (both firms and investors) expect the transparency of an exchange with a reputation ρ_t to be:

$$\gamma_t = \rho_t \bar{q} + (1 - \rho_t) q_t^M, \tag{17}$$

where q_t^M is the listing standard endogenously set by the value maximizing exchange. Let ρ_1^G, ρ_1^B, or ρ_1^N respectively denote the updated value of the exchange's time 1 reputation, conditional on the firm listed at time 0 being revealed at time 1 to be of type G, or type B, or if no firm is listed by the exchange at time 0. These are given by:

$$\rho_1^B = \frac{\dfrac{(1-\bar{q})(1-\omega)\beta_0^*\rho_0}{\omega + (1-\bar{q})(1-\omega)\beta_0^*}}{\dfrac{(1-\bar{q})(1-\omega)\beta_0^*\rho_0}{\omega + (1-\bar{q})(1-\omega)\beta_0^*} + \dfrac{(1-q_0^M)(1-\omega)\beta_0^*(1-\rho_0)}{\omega + (1-q_0^M)(1-\omega)\beta_0^*}}\ , \tag{18}$$

[30]Our results remain qualitatively unchanged even if do not adopt this normalization, but allow for a number of firm to apply for listing at a given date. In this case, the reputation updating occurring at time 1 will be based on the fraction of firms applying for listing which are accepted by the exchange at time 0, and on the proportion of the firms listed at time 0 which turn out to be good or bad at time 1.

[31]We assume that this fees is payable only upon listing. Further, the fee is not charged on a firm when it separates itself in equilibrium (since there is no information production in this case, so that the exchange's listing standard cannot be said to have created value for the firm in this case).

$$\rho_1^G = \frac{\dfrac{\omega\rho_0}{\omega + (1-\bar{q})(1-\omega)\beta_0^*}}{\dfrac{\omega\rho_0}{\omega + (1-\bar{q})(1-\omega)\beta_0^*} + \dfrac{\omega(1-\rho_0)}{\omega + (1-q_0^M)(1-\omega)\beta_0^*}}, \tag{19}$$

$$\rho_1^N = \frac{\bar{q}\rho_0}{\bar{q}\rho_0 + (1-q_0^M)(1-\rho_0)}. \tag{20}$$

At time 0, the value-maximizing exchange chooses its listing standard q_0^M in order to maximize the present value of cash flows received from listing fees over time 0 and time 1, given by:

$$\begin{aligned}\pi_0(q_0^M) = {} & [\omega + (1-q_0^M)(1-\omega)\beta_0^*]\,kV_{H0} + \omega kV_{H1}^G \\ & + (1-q_0^M)(1-\omega)\beta_0^* kV_{H1}^B + q_o^M(1-\omega)\beta_0^* kV_{H1}^N - w(q_0^M).\end{aligned} \tag{21}$$

In the above objective, the first term on the right hand side gives the exchange's cash flow from listing fees at time 0. The sum of the second, third, and fourth terms give the present value of time 1 listing fees collected by the exchange, with each individual term giving the listing fee depending on whether the firm listed at time 0 turns out to have been good, bad, or no firm was listed at time 0 (we use V_{H1}^G, V_{H1}^B, and V_{H1}^N respectively to denote the total equity values of a firm listed at the high share price p_H in the exchange at time 1, corresponding to each of these three possible cases). The last term on the right hand side gives the

verification and regulation cost of the exchange at time 0. Thus, the value-maximizing exchange M faces a dynamic trade-off in choosing its listing standard at time 0. On the one hand, lowering the listing standard increases current listing fees to the exchange, and also reduces current verification costs. However, doing so increases the chance of losing reputation at time 1, thus reducing the market value of the firms listed at time 1, and consequently the exchange's time 1 cash flows from listing fees. The listing standard chosen by the exchange at time 0 emerges from this trade-off.

At time 1, the value maximizing exchange has no concern about losing reputation (being the last period), and it sets the lowest possible standard, $q_1^{M*} = 0$. Using this in the first order condition for q_0^{M*} and simplifying, we get:

$$(1 - \omega)\beta_0^* k [V_{H1}^N - V_{H1}^B - V_{H0}] = w'(q_0^M). \quad (22)$$

We now study the equilibrium with endogenous listing standards, and the effect of exchange reputation on listing standards.

Proposition 7 (Endogenous Listing Standard Choice). *The equilibrium listing standards chosen by the type M exchange is given by: $0 \leq q_0^{M*} < \bar{q}$, and $q_1^{M*} = 0$. The type S exchange, on the other hand, always sets the highest possible standard, $q_0^{S*} = q_1^{S*} = \bar{q}$.*

The above proposition establishes the important role of reputation in motivating the value maximizing exchange (whose behavior is what we are concerned about here) to keep its listing standards high (in the current period). Reputation acts as a device which enables the exchange to commit to investors and firms that it will not lower its standards excessively in order to attract a larger volume of firms to list on it, or to simply reduce verification costs. We will see later that the role of reputation will become even more important in this regard when we introduce competition among exchanges.

Proposition 8 (Listing Standards and Exchange Reputation). *Let $\bar{q} > \hat{q}$, and $\rho_0 < \hat{\rho}$ (both defined in the appendix). Then, the listing standard chosen by the value-maximizing exchange, q_0^{M*}, is increasing in its current reputation.*

This proposition illustrates the variation of listing standards with the value maximizing exchange's current reputation. When the exchange is concerned with building reputation, the listing standard set by the value maximizing exchange is increasing in its current reputation. This is because, the greater the current

reputation of the exchange, the more it has to lose from lowering standards if its current reputation is greater. (The parametric values on ω, q that we have imposed ensure that the exchange is operating in the range of values where its concern for building reputation is the strongest.[32])

7. Competition Among Exchanges and Listing Standard Choice

In this section, we examine the impact of competition among exchanges on the exchanges on their choice of listing standard. In order to allow for competing exchanges, we enrich the model structure used in the previous section further by allowing each exchange to make two-sided errors when screening firms that apply for listing, as follows:

$$\Pr\{\text{accepted} \mid f = G\} = \eta, \quad \Pr\{\text{accepted} \mid f = B\} = \eta - q_t, \tag{23}$$

with each type of firm rejected with the complementary probability; $q_t \in [0, \bar{q}]$, and $q_t \leq \bar{q} < \eta < 1$. Notice that this modified evaluation technology makes the model slightly more realistic by allowing for a positive probability of the type G firm getting rejected by any exchange (since $\eta < 1$); setting $\eta = 1$ gives us the same listing procedure as in the previous section. Note also that, even under this modified listing technology, a type G firm will continue to be accepted by an exchange with a greater probability than type B.

As before, there are two exchanges X and Y. In a setting with competition between exchanges, one has to allow for the possibility that a firm which has been rejected for listing by one exchange might apply for listing to the other exchange in equilibrium.[33] Therefore, we will denote the prior probability of an exchange of a firm approaching it for listing to be type G by ω^E, E = X, Y (notice that the quality of the pool of firms applying for listing in equilibrium may now vary across exchanges). The objective of each value maximizing exchange E, E = X, Y, is now modified to:[34]

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[32]Notice that, if these parametric restrictions are not satisfied, the relationship between the current exchange reputation and listing standard is ambiguous. For instance, when ρ_0 is close to 1, the exchange has an incentive to "milk" its current reputation by lowering standards and increasing volume. However, as far as we can see, this effect is primarily due to the fact that we limit ourselves to a two-period reputation model. We find that, once we include a larger number of future periods in our model, the number of future periods that the exchange has to enjoy its reputation becomes larger, and the incentive to "live off" its current reputation by lowering standards prevails only for a smaller range of parameter values, since any such move imposes a bigger penalty on the exchange by hurting its revenue stream over a larger number of future periods.

[33]We do not allow dual-listing here, focussing instead on how the competition between two exchanges interacts with the reputation of the exchange in determining the listing standard. It is easy, however, to extend the model in this direction.

[34]The reputation formation process here is essentially the same as in the previous section. Thus, at any date t, t = 0, 1, outsiders assess that each exchange E, E ∈ {X, Y}, is of the standard maximizing type (S) with the probability ρ_t, and of the value-maximizing type (M) with the complementary probability.

$$\pi_0^E(q_0^E) = [\omega^E\eta + (\eta - q_0^E)(1-\omega)\beta_0^{E*}]kV_{H0}^E + (\eta - q_0^E)(1-\omega^E)\beta_0^{E*}kV_{H1}^{EB} + \omega^E\eta kV_{H1}^{EG} + (1-\eta+q_0^E)(1-\omega^E)\beta_0^{E*}kV_{H1}^{EN} - w(q_0^E). \quad (24)$$

We now characterize the equilibrium with endogenous listing standards and competing exchanges.

Proposition 9 (Equilibrium with Competing Exchanges). *Let $N_\ell^X \leq N_\ell^Y$, with $\rho_0^X < \rho_0^Y$.*

(i) If ρ_0^X, $\rho_0^Y < \bar{\rho}$ (defined in the appendix), then the high reputation exchange Y sets higher current listing standards than the low reputation exchange X in equilibrium: $q_0^{Y*} > q_0^{X*}$.

(ii) Each firm first applies for listing to the higher reputation exchange, moving on to the lower reputation exchange only if rejected.[35]

The above proposition examines the case where both exchanges have similar investor bases, and compete only through listing standards (one can think of this case as two exchanges competing in the same country, dropping our earlier interpretation of X as the domestic exchange and Y as the foreign exchange). In this case, the exchange Y has an advantage in that it can use its greater reputation as a device to commit to outsiders that its listing standards are higher than those of exchange X. To see why, note that the listing standard that would be set by each exchange as a monopolist serves as an upper bound for the listing standard set by that exchange in a setting with competition. Further, recall that the listing standard when each exchanges act as a monopolist is increasing in current reputation. Given this, firms would apply first to exchange Y, ceteris paribus (to take advantage of the greater transparency associated with higher listing standards), applying to the lower reputation exchange X only if they are rejected by exchange Y.

We now study how competition interacts with considerations of building and maintaining reputation in determining exchanges' listing standards. In the next two propositions, denote by q_0^{Xm} and q_0^{Ym} the equilibrium listing standards that would set by exchanges X and Y respectively if they are monopolists. Denote the corresponding equilibrium listing standards when the two exchanges compete by q_0^{Xc} and q_0^{Yc} respectively.

Proposition 10 (Competition and Listing Standard Choice). *Let $N_\ell^X \leq N_\ell^Y$, $\rho_0^X < \rho_0^Y$, and $\omega < \hat{\omega}$ (defined in the appendix). Then, in an equilibrium where the high reputation exchange sets the higher listing standard than the low reputation exchange:*

[35]Note that, since listing fees charged by exchanges are endogenous here, no condition on the magnitude of these fees are required for this proposition to hold (unlike in earlier sections, when listing costs were exogenous). Since exchanges charge a fraction $k < 1$ of market capitalization as fees, it always makes sense for firms to obtain a listing on that exchange where their equity will be more highly valued.

(i) The listing standard set by the high reputation exchange Y will be the same as would be set by the same exchange when it is a monopolist ($q_0^{Yc} = q_0^{Ym}$).

(ii) The listing standard set by the low reputation exchange in this case is lower than that set by the same exchange when it is a monopolist ($q_0^{Xc} < q_0^{Xm}$).

The above proposition isolates the effect of competition on the endogenous choice of listing standard by the two exchanges. Since the two exchanges have similar investor bases, and compete only through listing standards, we saw in proposition 9 that the higher reputation exchange sets higher listing standards in equilibrium, and the lower reputation exchange sets lower listing standards. Thus, exchange Y has an applicant pool of the same volume and quality as it would have if it were a monopolist, since all firms apply first to exchange Y, going to X only if rejected by Y. The solution to the higher reputation exchange's maximization problem is the same as that when it is a monopolist, resulting in its setting the same listing standard as it would in that case. The lower reputation exchange, on the other hand, now faces a reduction in the size and quality of the pool of applicant firms compared to the case when it is a monopolist (since only firms rejected by exchange Y apply for listing on exchange X). Given this, the solution to its optimization problem under competition involves setting a lower equilibrium listing standard than that set by when it is a monopolist.

The next proposition studies the effect of competition between exchanges on their listing-standard choice when the two exchanges differ in the size of their low-cost investor-base.

Proposition 11 (Exchange Reputation vs. Size of Low-cost Investor Base). *Let $\rho_0^X < \rho_0^Y$, with $N_\ell^X > N_\ell^Y$. Further, let $N_\ell^Y < \bar{N}_\ell^Y$, and $N_\ell^X \geq \bar{N}_\ell^X$. Then:*

(i) If $\rho_0^Y < \rho_1$ (defined in the appendix), then exchange X sets $q_0^{Xc} = q_0^{Xm}$, and exchange Y sets $q_0^{Yc} < q_0^{Ym}$.

(ii) If $\rho_0^Y \geq \rho_2$ (defined in the appendix), then exchange X sets $q_0^{Xc} < q_0^{Xm}$, and exchange Y sets $q_0^{Yc} = q_0^{Ym}$.

The assumption here is that the less reputable exchange X has a much larger investor base than the more reputable exchange Y, so that the equilibrium will be one where the low-cost investors are the marginal information producers if the firm listed on exchange X alone, while it will be one in which the high-cost investors are the marginal information producers if the firm is listed in exchange Y alone. The interesting question here is whether this disadvantage of exchange Y in terms of low-cost investor base can be bridged by its greater reputation relative to exchange X. This is indeed the case if the reputation of exchange Y is overwhelmingly larger than that of exchange X. In this case, exchange Y acts like a monopolist, setting the

same listing standard under competition that it would set as a monopolist. Firms, inferring this equilibrium behavior, first approach it for a listing, going to exchange X only if rejected; the equilibrium listing standard set by exchange X is correspondingly lowered (relative to the case when it is a monopolist) to adjust for the smaller, poorer quality, applicant pool faced by it. On the other hand, if the reputation levels of the two exchanges are somewhat close (so that the advantage enjoyed by exchange X in terms of its larger base of low-cost information producers cannot be overcome by exchange Y even by setting the same listing standard that it would set if it were a monopolist), then it will be exchange X which acts like a monopolist in equilibrium. In this case, exchange Y will be the one which has to face the poorer quality applicant pool consisting of rejects from exchange X, consequently lowering its listing standards (relative to the monopolist situation) in order to maximize its long-term profit in the face of such an applicant pool.

8. Co-operation and Competition Among Exchanges

We now allow for the possibility of co-operation as well as competition among exchanges. In order to analyze the most interesting scenario, we assume that there are three exchanges to begin with: X, Y, and Z. Our objective is to study the implications of a merger or alliance between exchanges X and Z, and the subsequent competition between the combined exchange (denoted by XZ) and the stand-alone exchange Y on the equilibrium behavior of both these exchanges, with implications for firms planning to obtain a listing on one of these exchanges.

A merger between exchanges here means that all investors who previously traded on any one of these two exchanges X and Z can now trade in a common market place consisting of the combined exchange XZ. Further, stocks which were previously listed on any one of these two exchanges X or Z are now listed in the combined exchange XZ. Thus, one effect of the two exchanges X and Z merging is that the pool of low-cost investors available to trade in the stocks of firms listed on either one of the two exchanges X and Z now increases to $N_{\ell}^{XZ} = N_{\ell}^{X} + N_{\ell}^{Z}$.

Another effect of the merger between exchanges X and Z is on the listing standards endogenously chosen by the combined exchange XZ, and by the stand-alone exchange Y, and on the listing fees set by these exchanges. For ease of exposition (and following the plan of previous sections), we will temporarily take this second effect to be exogenous: i.e, we first study below how the listing choice of firms are affected by a merger between exchanges, taking as exogenous the listing standards q^X, q^Y, and q^Z, and the listing fees charged by

the three exchanges. We will then go on to endogenize the listing standards and listing fees chosen by the combined exchange XZ and the stand-alone exchange Y.

We assume that, prior to the merger between X and Z, exchange Y has a greater reputation compared to the two exchanges X and Z individually, so that $\rho^Y > \max \{\rho^X, \rho^Z\}$. We further assume that, prior to the merger, exchange Y has the largest number of low-cost investors among the three exchanges: i.e., $N_\ell^Y > \max \{ N_\ell^X, N_\ell^Z \}$. These two assumptions together imply (using proposition 10) that, prior to the merger between X and Z, exchange Y dominates these two exchanges (in the sense that all firms would prefer to be listed on this exchange rather on the other two). This is clearly the most interesting scenario (since the merger between X and Z has the potential to overcome the dominance of exchange Y) which we choose to focus on here.[36]

Proposition 12 (Firm Listing Choice with Co-operation and Competition among Exchanges) *Let the listing standard of exchange Y be higher than that of the combined exchange XZ ($q_t^Y > q_{tZ}^X$), and let the listing fees of all exchanges be the same, so that $F^X = F^Y = F^Z = F$. Further, let $F > \bar{F}$ (so that dual listing is not optimal). Then:*

(i) If $N_\ell^Y \geq N_\ell^{XZ}$, the firm lists on exchange Y.

(ii) If $N_\ell^Y < N_\ell^{XZ}$, the firm chooses between exchanges XZ and Y as follows:

(a) If $N_\ell^{XZ} \geq \bar{N}_\ell^{XZ}$, with $N_\ell^Y < \bar{N}_\ell^Y$ and $q^Y < \hat{q}^Y$, the firm lists on the allied exchange XZ;

(b) Otherwise, it lists on exchange Y.

In the above situation, the listing standard set by the stand-alone exchange is higher than that of the combined exchange, and the listing fees are assumed to be the same across exchanges. Therefore, the stand-alone exchange will clearly dominate even after the merger between X and Z if the number of low-cost investors in that exchange is more than that in the allied exchange, so that all firms prefer to be listed on that exchange. If, however, the number of low-cost investors in the combined exchange is greater than that in the stand-alone exchange, then firms will make their listing choice by trading off the advantage provided by the stand-alone exchange in terms of a higher listing standard against the benefit of having a greater number of low-cost investors in the combined exchange. In particular, if the advantage of the merged exchange in terms of the size of its low-cost investor base dominates the effect of the higher listing standard set by the stand-alone

[36]In other words, these two assumptions are not essential for our analysis, but simply characterize the most interesting case where the stand-alone exchange is the dominant exchange prior to the merger. The analysis of the cases where the stand-alone exchange is not the dominant exchange before the merger follows along very similar lines, and is available to interested readers upon request.

exchange Y (as in (iia)), then all firms will prefer to be listed in the merged exchange; otherwise, they continue to prefer to be listed in the stand-alone exchange. In the following proposition, we endogenize the listing standards and fees chosen by various exchanges. In the following, denote by ρ_0^{XZ} and ρ_0^{Y} respectively the current (i.e., time 0) reputations of the combined exchange XZ and the standard-alone exchange Y.

Proposition 13 (Endogenous Listing Standard Choice with Co-operation and Competition).

Let $\omega < \hat{\omega}$, with $\rho_0^{XZ} < \rho_0^{Y}$. Then:

(i) If $N_\ell^{XZ} \leq N_\ell^{Y}$, then the stand-alone exchange Y sets a higher listing standard compared to the combined exchange XZ. In this case, the listing standard set by exchange Y will be the same as that set by it before the merger between exchanges X and Z.

(ii) If, however, $N_\ell^{XZ} > N_\ell^{Y}$, with $N_\ell^{Y} < \bar{N}_\ell^{Y}$, $N_\ell^{XZ} \geq \bar{N}_\ell^{XZ}$, and $\rho_0^{Y} < \rho_3$, then:

(a) The listing standard set by exchange Y will be the lower than that set by it before the merger between exchanges X and Z.

(b) Further, if $\rho_0^{XZ} \geq \hat{\rho}^{XZ}$, the listing standard set by the combined exchange XZ will be higher than the listing standard set by either of the two exchanges X and Z before their merger: i.e, $q_0^{XZ} > Max\ \{q_0^{X}, q_0^{Z}\}$.

As we saw in the case of competition between two exchanges in proposition 10 and 11, the key question driving the results above is whether it is the combined exchange XZ or the stand-alone exchange Y which is the dominant exchange (ie. the exchange which firms prefer to approach first for a listing, going to the other exchange only if rejected). After the merger between exchanges X and Z, the size of the pool of low-cost investors trading in the combined exchange expands to equal the total of the number of low-cost investors trading in the individual exchanges X and Z. However, exchange Y retains the advantage of having a greater reputation than the combined exchange XZ. If, even after the merger between X and Z, the low-cost investor base of exchange Y continues to be larger than that of the combined exchange XZ, then exchange Y continues to be the exchange of first choice, so that its listing standard is unaffected by the merger between the two exchanges X and Z competing with it. In contrast, if this merger (and the resulting larger low-cost investor base) makes the combined exchange the dominant one among firms wanting to get listed (through the effect of the larger low-cost investor base of the allied exchange dominating the higher reputation of the stand-alone exchange Y), then the stand-alone exchange Y will attract only a lower-quality pool of applicant firms, thus forcing it to lower its listing standards in equilibrium. Finally, if the combined exchange's reputation is not too

low (so that $\rho_0^{XZ} \geq \hat{\rho}^{XZ}$), then the equilibrium listing standard set by this exchange will be higher than that set by either of the individual exchange X or Y before their merger (since the equilibrium listing standard set by the combined exchange takes into account the better quality of its pool of applicant firms relative to either individual exchange X or Y before their merger).

It is important to note that the above result is not dependent on how the reputation of the combined exchange relates to that of the reputation of the exchanges X and Z prior to their merger. While, in general, one would expect the reputation of the merged exchange to be some kind of weighted average of the reputations of the two constituent exchanges X and Z, the result holds even if this reputation is equal only to that of the lower-reputation exchange (i.e., $\rho^{XZ} = \min \{ \rho^X, \rho^Z \}$), provided that this reputation is above a certain threshold value $\hat{\rho}^{XZ}$.

9. Implications of the Model

(i) Listing on Foreign Exchanges Alone, Dual Listing, and Global IPOs: The first implication of our model relates to the situations under which firms will list on a foreign exchange alone, or dual list with a foreign exchange (rather than list only on an exchange in their own country). Firms will list on a foreign exchange alone if most of the group of investors who have a comparative advantage in evaluating their firm (low-cost investors) trade in the foreign exchange rather than in the domestic exchange, and the foreign exchange has the same or greater transparency than the domestic exchange. This applies, for instance, in the case of many high technology firms from abroad (e.g., Israel) obtaining a NASDAQ National Market Listing rather than listing on an exchange in their own country (with a smaller base of investors with a comparative advantage in evaluating such firms).[37] Firms will dual-list when they have a significant base of low-cost information producers in their own country, but would like to enlarge that base by listing in the foreign exchange, or take advantage of the higher transparency of the foreign exchange, or both. Our model predicts that the kinds of firms that will be likely to take advantage of dual-listing will be those about which foreign investors have, for various reasons, a significant amount of information available to them (so that a substantial number of investors with a cost advantage in evaluating the firm are present in the foreign market). Consistent with this implication,

[37]Evidence supporting this implication is provided by Blass and Yafeh (2000) who find that high-tech firms from Israel are more likely to be listed on the Nasdaq rather than on the Tel Aviv stock exchange, despite the fact that it would be cheaper (in terms of listing fees) for these firms to list on the Tel Aviv exchange. Additional anecdotal evidence supporting this implication is provided by high-tech firms from other countries (e.g., France) listing on the Nasdaq without obtaining a listing on any exchange in their home country.

Pagano, Roell and Zechner (2002) find that European firms which choose to obtain an additional listing on the NYSE are either high-tech companies, or large export-oriented companies which have become very familiar to American investors through having used a product or service of the listing firm.[38]

(ii) Price Effects of Cross-Listings: Our model predicts a positive announcement effect of a listing decision on the equity of the listing firm in the event that the foreign exchange has a higher listing standards than the domestic exchange, or a substantial base of investors who have a comparative advantage evaluating the firm (or both). In the absence of these two factors, our model predicts a negative or zero announcement effect on firms that list equity on a foreign exchange (since such a listing might be value-reducing, if there are significant additional listing costs to be incurred by the firm to obtain such a listing). Thus, when European firms list their equity in the U.S., our model predicts a positive listing (and therefore announcement) effect. However, when an American firm lists its equity on a European exchange, our model predicts a negative or zero listing (and therefore announcement) effect on stock prices.[39]

(iii) Cross-Listing and Financial Analyst Following: A directly testable implication of our model is that cross-listing by foreign firms, say, at the NYSE, should be followed by increased analyst coverage (since increased information production, and increased transparency arising from higher listing standards are the two factors motivating firms to cross-list in our model). This also implies that, holding listing standards constant, the increase in analyst coverage should be larger for the set of firms listing on the exchange with greater listing costs (since the advantage of listing on that exchange has to compensate for the higher listing cost in equilibrium). In a comparative study of firms cross-listed on the NYSE or the LSE, Baker, Nofsinger, and Weaver (1999) provides strong empirical support for this implication. First, they document that firms cross-listed on either one of these exchanges experienced a significant increase in analyst following. Second, in the

[38]Additional evidence supporting this implication is provided by Saudagaran and Biddle (1995) and Saudagaran (1988), who find a strong association between the foreign listing location of a given firm and the level of its exports to that country. While such evidence can also be interpreted as a foreign listing helping the firm in the product markets in that country (rather than a presence in the product market motivating a foreign listing), anecdotal evidence seems to indicate that the motivation goes both ways. For example, consider the following quote (WSJ, October 5, 1993) from one of the officers of Daimler-Benz, the German auto-maker, about its decision to list on the NYSE: 'We have 300,000 Mercedes drivers in the U.S., and about two-thirds of them are certainly wealthy,' says Mr. Liener, suggesting that the company's image will help it tap the U.S financial markets." Also, the listing of the German software firm SAP on the NYSE was motivated, at least partly, by the presence in the U.S of a large number of software and other high-technology professionals and investors with considerable familiarity with evaluating and investing in technology firms (Economist, August 1998).

[39]The empirical evidence seems to support this implication of our model. Most research which has focussed on foreign firms listing on the U.S market (e.g., Jayaraman, Shastri, and Tandon (1993), Foerster and Karolyi (1993), Alexander, Eun, and Janakiraman (1991)) have concluded that the announcement of a foreign listing on a U.S exchange is associated with a positive market reaction. In contrast, the empirical research focussing on overseas listing of U.S firms (e.g., Howe and Kelm (1987), Lee (1991), or Lau, Diltz and Apilado (1994)) has found either negative or insignificant changes in shareholder wealth.

set of firms which seem to broadly satisfy the listing standards of either exchange, the increase in analyst following is significantly greater for firms cross-listed on the NYSE, where both the direct as well as indirect listing costs are significantly greater.

(iv) Exchange Reputation, Listing Standards, and Competition Among Exchanges: Our model predicts that, greater the reputation of the exchange, higher the listing standard set by that exchange. Further, an exchange's concern for its future reputation allows it to commit not to lower listing standards excessively. Finally, when two exchanges compete, the effect of this competition on listing standards depends, among other things, on the reputation level of the two exchanges, and the base of low-cost investors trading in each exchange. If the low-cost investor base is the same for both exchanges, then the higher reputation exchange is dominant, and competition may not affect its listing standards at all. In contrast, the lower reputation exchange sets significantly lower standards (compared to the case where it does not face any competition).[40] Alternatively, if the investor base of the two exchanges are different, so that the higher reputation exchange has a significantly smaller base of low-cost investors than the lower reputation exchange, it is the higher reputation exchange that has to lower its listing standards in equilibrium.[41] Thus, we show that a "race to the bottom" in listing standards need not materialize as a result of competition between exchanges. In fact, we show that exchanges with different reputations and therefore listing standards can co-exist.

(v) Co-operation and Competition Among Exchanges: There has been a recently accelerating trend of mergers or alliances between exchanges in a bid to improve their competitive position against other exchanges. Our model provides several insights into the effects of such mergers or alliances between exchanges not only on the exchanges involved in the merger, but also on the exchanges competing with the combined exchange. First, our model demonstrates how two smaller exchanges can improve their competitive position against a third,

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[40]One example that comes to mind is the competition between NYSE and the American Stock Exchange (AMEX), which have the same investor base. Clearly, the NYSE has significantly greater reputation and higher listing standards than the AMEX; it seems to be the case that, while competition between the two exchanges has not affected the NYSE listing standards in any significant way, the AMEX seems to be struggling to attract firms to list on that exchange.

[41]A real-world illustration of this implication is provided by the competition for listing firms from emerging market countries between the LSE and the NYSE, with the latter usually regarded as having a better reputation and higher listing standards than the LSE. Assuming that the two exchanges have perhaps similar investor bases in terms of their low-cost investor base in evaluating firms from emerging economies, our model predicts that the NYSE would not lower its listing standards in the presence of competition from the LSE, whereas the LSE would have to significantly lower its listing standards for such firms. In contrast, consider a potential attempt by the NYSE to attract listings from firms based in the U.K. In this case, since the LSE can be expected to have a considerable advantage in terms of its low-cost investor base capable of evaluating British firms, which may be large enough to overcome the advantage of the NYSE in terms of greater reputation and listing standards. If this is the case, competition from the NYSE would not induce the LSE to lower listing standards for British firms; if anything, the NYSE will have to lower its listing standards to attract British listings.

larger exchange by merging and thereby pooling their low-cost investor base.[42] Second, our model predicts the effect of a merger between exchanges on the listing standard set by the combined exchange and also by the other exchanges competing it. It is an often-expressed fear that, when two exchanges merge or form an alliance, the listing standard of the combined exchange will be set at the lower of the listing standards of the two constituent exchanges (the "lowest common denominator"). Our analysis indicates that this fear need not always be realized: the listing standard set by the combined exchange depends on the competitive position of this exchange subsequent to the merger. If this exchange is sufficiently dominant, then the listing standard set by it will in fact be *higher* than that of *either* of the exchanges forming the merger or alliance. In this case, exchanges competing with the combined exchange will have to optimally lower their listing standards as a result of the merger, since the quality of their applicant pool will be reduced by it.[43]

(vi) Competition, Listing Standards and the Optimal Regulation of Exchanges: Our analysis also contributes to the debate on the optimal regulation of exchanges after they go public and thus become value-maximizing corporations. Some have argued that exchanges be stripped of their self-regulatory authority after going public, with all such authority resting in a centralized regulatory authority common to exchanges.[44] First, our analysis suggests that even when exchanges act as value-maximizing entities, they have strong incentives to set appropriately high listing standards in order to protect their reputation and thus maximize their own long-run profits and therefore stock value. Second, our analysis implies that reposing all regulatory authority in a centralized agency and adopting a "one-size fits all" approach may affect the economic viability of value maximizing exchanges, since, in order to survive, exchanges need the flexibility to tailor their listing standards

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[42]To give a real-world illustration, consider the proposed tie-up (now aborted) between the London and Frankfurt stock exchanges. The stated objective of this alliance was to eventually let investors access the blue-chip stocks listed on either of the two exchanges through a single exchange: See, e.g., the news story titled, "European Stock Markets Sign Pact," *Wall Street Journal*, July 8, 1998. If consummated, such an arrangement would have enlarged the number of low-cost information producers available to evaluate stocks listed on either exchange to the sum of those trading in each exchange.

[43]A real-world illustration of this is provided by the merger of the Amsterdam, Brussels, and Paris stock exchanges to form "Euronext"in September 2000. One of the stated goals of the management of the combined exchange has been to tighten the disclosure requirements on firms listing on the combined exchange after the merger, which seems to be consistent with an *increase* in listing requirements.

[44] See, for instance, an article by Jeffrey Garten, Dean of the Yale School of Management ("How to Keep NYSE's Stock High," *Wall Street Journal*, January 2000). To quote: "If the exchange goes public, its self-regulating authority would create huge conflicts of interest between the Big Board's legitimate mandate to enrich its shareholders by attracting new listings, and the requirement to regulate many of those same shareholders as they trade on the exchange's floor. A second conflict would arise in setting listing requirements for new companies, as there would be a temptation to dilute standards or relax surveillance over them in order to sign up more corporate clients....A far better option is to strip the exchanges of most of their regulatory authority and to create one independent national self-regulating body....it could apply uniform standards on all market participants." A somewhat similar proposal was also endorsed by former SEC chairman Arthur Levitt (see, e.g., "SEC seeks One Market Regulator," *Washington Post*, Sept 22, 1999).

optimally to their pool of applicant firms, with the quality of this pool varying as a result of competitive pressures from other exchanges.

9. Conclusion

We have developed a theoretical analysis of the choice of firms of exchange to list equity (including dual listing), and of exchanges' choice of listing and disclosure standards for firms, taking into account considerations of building and preserving exchange reputation, and competitive pressures between exchanges. We assumed an equity market characterized by asymmetric information about firm's future cash flows, with firm insiders' information superior to that of outsiders. Outsiders, however, can reduce this informational disadvantage by producing (noisy) information at a cost to themselves. There are two kinds of investors in our model setting: sophisticated investors, with a cost advantage in producing information about the true value of firms ("low-cost investors"), and ordinary investors, who do not have such a cost-advantage ("high-cost investors"). The five important ingredients driving our analysis are as follows. First, the number of such low-cost information producers may vary from exchange to exchange. Second, different exchanges may have different listing and disclosure requirements, which not only affect the kind of firms that are listed, but the precision of the information available to outsiders in evaluating the firm. Third, exchanges choose their listing policy privately, and further, these listing policies evolve over time. Outsiders, therefore, can learn about how an exchange implements its listing policy only by studying the performance of firms which have obtained a listing on the exchange in previous periods. This performance, therefore, affects the exchange's "reputation" for adopting stringent listing procedures. Fourth, since these listing and disclosure requirements can be altered by the exchange over time, the possibility of gaining or losing reputation affects the endogenous choice of listing standards by the exchange. Finally, exchanges may alter these listing standards to compete with other exchanges for listing candidates, taking into account, at the same time, the impact of any alteration of these listing standards on their future reputation. Given these five ingredients, we solved for the kinds of firms which can benefit from listing at different exchanges as well as from multiple listings in various settings. We also solved for the exchange's endogenous choice of listing standards under different economic environments.

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APPENDIX

Proof of Proposition 1. A partially pooling equilibrium is a collection $\{n_H^*, \hat{n}_H^*, \theta^*, \beta^*, p_H^*, \alpha_\ell^*, \alpha_h^*, \delta_\ell^*, \delta_h^*, \lambda^*, p_L^*, n_L^*\}$ such that conditions (4) - (14) are satisfied. We will say that in a partially pooling equilibrium with $0 < \alpha_\ell < 1$ and $\alpha_h = 0$, investors with low information production cost are marginal information producers, while if $\alpha_\ell = 1$ and $0 < \alpha_h < 1$, investors with high information production are marginal information producers. This proof will be structured in three parts. In the first part, we will determine whether high-cost or low-cost investors will be the marginal information producers, given the amount of shares offered for sale in equilibrium by a good quality firm, n_H^*. In the second part, we will study the conditions for the existence of a partially pooling equilibrium for a given information production costs c. In the third and last part, we will characterize the overall equilibrium, and we will establish when low-cost investors are the marginal information producers.

Part 1. If $n_H^* \leq N_\ell$, the number of low-cost investors is sufficiently large with respect to the number of shares sold; hence, in this case, low-cost investors are the marginal information producers. Consider now the case in which $n_H^* > N_\ell$. Note now that, from (10) we have that in equilibrium:

$$\lambda^*(n_H^*) \equiv \frac{\hat{n}_H}{n_H} = \frac{m}{m + n_L - n_H^*} \geq 1 - \gamma . \tag{A1}$$

By direct calculation, note that $\lambda^*(N_\ell) > 1 - \gamma$ and that λ^* is an increasing, convex function of n_H^*, with $\lambda^*(n_L) = 1$. Consider now the fraction λ that can be sustained when all low-cost investors produce information, that is when $\delta_\ell = \alpha_\ell = 1$. This is given by:

$$\bar{\lambda}(n_H^*) = 1 - \frac{\gamma N_\ell}{n_H^*}, \tag{A2}$$

since $\hat{n}_H = n_H - \gamma N_\ell$. Note next that $\bar{\lambda}(N_\ell) = 1 - \gamma$, and that $\bar{\lambda}(n_H^*)$ is an increasing, concave function of n_H^* with $\lambda(n_L) < 1$. We will consider the case in which λ^* and $\bar{\lambda}$ have (two) intersections, $N_0(N_\ell)$ and $N_1(N_\ell)$, with $N_0 < N_1$. Note that if these curves have no intersections, low-cost investors are always marginal information producers. With two intersections, high-costs investors are marginal information producers when $N_0 < n_H^* < N_1$. For simplicity, we will assume that N_1 is large, so that it will never be binding in equilibrium (it is straightforward to verify that this will be the case when n_L is sufficiently large). This implies that if $n_H^* \leq N_0$,

low-cost investors are marginal information producers, and if $n_H^* > N_0$, high-cost investors are the marginal information producers. Finally, note that $N_0(N_\ell)$ is a strictly increasing function of N_ℓ.

Part 2. We consider now the condition for the existence of a partially pooling equilibrium for a given cost of information production, c. Set (8) to hold as an equality with $c_\ell = c$, and let $\psi \equiv 1 - \theta$. After repeated substitutions, we can simplify (7) and (8) into:

$$H(\psi, n_H) \equiv (1-\psi)\frac{n_H}{m+n_H}k^G + \psi n_B \frac{k^B - 1}{m} = 0, \tag{A3}$$

$$G(\psi, n_H, c/I) \equiv \psi\gamma\left[\frac{1}{n_H} - \frac{k^B - 1}{m}\right] - \frac{c}{I} = 0. \tag{A4}$$

A solution to (A3) and (A4) with $0 \le \psi \le 1 - \omega$ will give the desired $\{n_H^*, \theta^*\}$ pair for a given c (if there are multiple solutions, choose the one with the minimum n_H). Consider now (A4), which may be re-written as:

$$n_H = g(\psi) \equiv \frac{\psi}{c/\gamma I + (k^B - 1)\psi/m}. \tag{A5}$$

After some algebra, it may be verified that hat $g(\psi)$ is an increasing and concave function of ψ, with $g(0) = 0$. Define $\hat{n}_H = g(1 - \omega)$. Consider now condition (A3), and note that it may be rewritten as:

$$\psi n_H^2(k_B - 1) + n_H[(1-\psi)k_G + \psi(k_B - 1) - 1]m - m^2 = 0. \tag{A6}$$

Solving (A6) for n_H, define $n_H = h(\psi)$ to be the solution in which the root with the positive sign is taken. Note that the discriminant of (A6) is always positive, so a solution exists. Furthermore, from implicit function differentiation of (A3), we have that:

$$h'(\psi) = -\frac{\partial H/\partial\psi}{\partial H/\partial n_H} > 0, \tag{A7}$$

since it may be immediately verified that $\partial H/\partial\psi < 0$, and $\partial H/\partial n_H > 0$. Finally, let:

$$\underline{n}_H \equiv h(0) = \frac{m}{k^G - 1}, \text{ and}$$
$$\bar{n}_H \equiv h(1-\omega). \tag{A8}$$

Since $g(0) = 0 < \underline{n}_H = h(0)$, we have that $\hat{n}_H > \bar{n}_H$ and continuity of (A5) together ensure existence of a solution to the system (A3) - (A4). Furthermore, from (A5), the condition $\hat{n}_H > \bar{n}_H$ is verified if and only if:

$$c < c_s \equiv (1-\omega)\gamma\left[\frac{1}{\bar{n}_H} - \frac{k_B - 1}{m}\right]I. \tag{A9}$$

Part 3. Let $\{ n_H^*(c), \theta^*(c) \}$ a solution to (A3) - (A4) for a given information production cost c. From implicit function differentiation of (A3) - (A4), we have that:

$$\frac{\partial n_H}{\partial(c/\gamma I)} = -\frac{\begin{vmatrix} \partial H/\partial\psi & 0 \\ \partial G/\partial\psi & -1 \end{vmatrix}}{\begin{vmatrix} \partial H/\partial\psi & \partial H/\partial n_H \\ \partial G/\partial\psi & \partial G/\partial n_H \end{vmatrix}} > 0, \tag{A10}$$

since $\partial H/\partial\psi < 0$, and $h'(\psi) < g'(\psi)$ implies that the Jacobian determinant in (A10) is negative. Hence, $\partial n_H^*(c)/\partial c > 0$. Let then $\bar{N}_\ell(c_\ell)$ be implicitly defined by the equality $N_0(\bar{N}_\ell) = n_H^*(c_\ell)$. The proof is concluded by noting that increasing monotonicity of $N_0(\bar{N}_\ell)$ implies that if $N_\ell \geq \bar{N}_\ell(c_\ell)$ low-cost investors are marginal information producers, and if $N_\ell < \bar{N}_\ell(c_\ell)$ high-cost investors are marginal information producers. QED

Proof of Proposition 2. The advantage of listing on exchange X rather than exchange Y is given by:

$$W^G(\gamma^X, \gamma^Y, \Delta F) \equiv \frac{mk^G I}{m + n_H^{*X}(\gamma^X)} - \Delta F - \frac{mk^G I}{m + n_H^{*Y}(\gamma^Y)}, \tag{A11}$$

where $\Delta F = F^X - F^Y$. Let $F^X = F^Y$. The objective of a type G firm is to minimize dilution of its initial shareholders; hence, a firm will choose the exchange that allows to raise the desired investment I by selling the lowest number of shares, n_H^*. Note that, from A(10), the number of shares sold on an exchange, n_H^*, is a decreasing function of the precision γ. If $N_\ell^Y \geq N_\ell^X$, two cases are possible. (i) if in both exchanges the same

group of investors are marginal (that is, either the low-cost or the high-cost investor is the marginal information producer), then (A10) and $\gamma^Y > \gamma^X$ together imply that exchange Y strictly dominates. (ii) the second possibility is that, since $N_\ell^Y \geq N_\ell^X$, low-cost investors are marginal information producers in exchange Y, while high-cost investors are information producers in exchange X. In this case, again, (A10) implies that exchange Y dominates exchange X. QED

Proof of Proposition 3. If $N_\ell^X > N_\ell^Y$, then the firm chooses as follows. (i) if $N_\ell^Y \geq \bar{N}_\ell^Y$, then low-cost investors are marginal on exchange Y, and (A10) with $\gamma^Y > \gamma^X$ together imply that $n_H^{*Y} < n_H^{*X}$, and firms prefers exchange Y. (ii) if $N_\ell^Y < \bar{N}_\ell^Y$, then high-cost investors are marginal information producers on exchange Y. Hence, if (a) $N_\ell^X \geq \bar{N}_\ell^X$, then low-cost investors are marginal information producers on exchange X., and firms prefer exchange Y only if $n_H^{*Y}(\gamma^Y) < n_H^{*X}(\gamma^X)$. From (A10), this will be the case for $\gamma^Y > \bar{\gamma}^Y$, where $\bar{\gamma}^Y$ is implicitly defined by $n_H^{*Y}(\bar{\gamma}^Y) = n_H^{*X}(\gamma^X)$. (b) if, instead, $N_\ell^X < \bar{N}_\ell^X$, then high-cost investors are marginal information producers on exchange X as well, and $\gamma^Y > \gamma^X$ implies that a firm prefers exchange Y. QED

Proof of Proposition 4. Let now $F^Y > F^X$ and $\Delta F > 0$. Given γ, from (A11) define $\bar{\gamma}^Y(\Delta F)$ implicitly by setting $W^G(\gamma^X, \gamma^Y, \Delta F) = 0$. Hence, from direct calculation, (A10) implies that $W^G > 0$ if and only if $\gamma^Y < \bar{\gamma}^Y(\Delta F)$, so that the firm prefers exchange X over Y. QED

Proof of Proposition 5. If $N_\ell^Y \geq \bar{N}_\ell^Y$, then from Proposition 2 we know that exchange Y dominates exchange X, and single listing on Y is the optimal choice. If $N_\ell^Y < \bar{N}_\ell^Y$, then high-cost investors are marginal information producers in exchange Y, and two cases may arise. If $N_\ell^Y + \bar{N}_\ell^Y < \bar{N}_\ell(c_\ell) \equiv \bar{N}_\ell^D(c_\ell)$, then high-cost investors are marginal information producers in the pooled market. In this case, firms do not benefit from dual listing, but must pay the additional listing fee, F^X. Hence, in this case, single listing on exchange Y dominates dual listing. If instead $N_\ell^Y + \bar{N}_\ell^Y > \bar{N}_\ell(c_\ell) \equiv \bar{N}_\ell^D(c_\ell)$, then dual listing may dominate if the additional listing fee is not too large. From (A11), the advantage of dual listing rather than single listing on exchange Y only is given by:

$$W^G(\gamma^Y, F) = \frac{mk^G I}{m + n_H^{*D}(\gamma^Y)} - F - \frac{mk^G I}{m + n_H^{*Y}(\gamma^Y)}, \qquad \text{(A12)}$$

where n_H^{*D} is the total number of shares sold when the firm lists on both exchanges. The proof is concluded by defining $\bar{F}$ implicitly by $W^G(\gamma^Y, \bar{F}) = 0$. QED

Proof of Proposition 6. (i) If $N_\ell^Y \geq \bar{N}_\ell^Y$, then low-cost investors are marginal information producers in exchange

Y, which will be the optimal choice (since $\gamma^Y > \gamma^X$). (ii) If $N_\ell^Y < \bar{N}_\ell^Y$ and $N_\ell^X < \bar{N}_\ell^X$, then the optimal listing decision will be as in Proposition 5. (iii) If $N_\ell^Y < \bar{N}_\ell^Y$ but $N_\ell^X \geq \bar{N}_\ell^X$, low-cost investors are marginal producers in the less transparent exchange, X, while high-cost investors are marginal information producers in the more transparent exchange. Hence, the only gain by listing on exchange Y is to increase transparency to γ^Y. A type G firm payoff from listing on exchange X, U^X, exchange Y, U^Y, or dual listing, U^D, are given by:

$$
\begin{aligned}
U^{GX}(\gamma^X, c_\ell, F) &= \frac{mk^G I}{m + n_H^{*X}(\gamma^X, c_\ell)} - F, \\
U^{GY}(\gamma^Y, c_h, F) &= \frac{mk^G I}{m + n_H^{*Y}(\gamma^Y, c_h)} - F, \\
U^{GD}(\gamma^G, c_\ell, 2F) &= \frac{mk^G I}{m + n_H^{*D}(\gamma^Y, c_\ell)} - 2F.
\end{aligned}
\tag{A13}
$$

Let $\hat{\gamma}$ such that $U^{GY}(\hat{\gamma}, c_h) = U^{GX}(\gamma^X, c_\ell)$. Then, single listing on Y dominates single listing on X if $\gamma^Y > \hat{\gamma}$, and single listing on X dominates single listing on Y if $\gamma^Y < \hat{\gamma}$. Let $\gamma^Y < \hat{\gamma}$. Then, let F^X be defined by $U^{GX} = U^{GD}$; then single listing on X is optimal on X if $F > F^X$, and dual listing is optimal if $F \leq F^X$. Let now $\gamma^Y \geq \hat{\gamma}$. Let $F^Y(\gamma^Y)$ be defined by $U^{GY} = U^{GD}$; then single listing in Y is optimal when $F > F^Y(\gamma^Y)$, and dual listing is optimal when $F < F^Y(\gamma^Y)$. The proof is concluded by setting $\bar{F}(\gamma^Y) = \max \{ F^X ; F^Y(\gamma^Y) \}$. QED

Proof of Proposition 7. The standard maximizing exchange S will minimize the probability of a loss of reputation by optimally setting the highest possible standards, that is $q_0^{S*} = q_1^{S*} = \bar{q}$. The value maximizing exchange M will set at time 1 the lowest possible standards, that is $q_1^{M*} = 1$. Furthermore, if $q_0^M = \bar{q}$, from (18) and (19) we get that $\rho_1^G = \rho_1^B = \rho_0$, so that $V_{H1}^G = V_{H1}^B$, and the first order condition (22) will never be satisfied. Hence, at an optimum, $0 \leq q_0^M < \bar{q}$. QED

Proof of Proposition 8. Consider the first order condition for q_0^M, equation (21), given by:

$$
H(q_0^M, \rho_0) \equiv (1 - \omega)\beta_0^* k [V_{H1}^N - V_{H1}^B - V_{H0}] - w'(q_0^M) = 0. \tag{A14}
$$

Consider then the updating rules (19) and (20), which may be re-written as:

$$
\rho_1^\tau = \frac{\rho_0}{\rho_0 + h^\tau(1 - \rho_0)}, \text{ with } \frac{\partial \rho_1^\tau}{\partial \rho_0} = \frac{h^\tau}{(\rho_0 + h^\tau(1 - \rho_0))^2}, \text{ for } \tau = N, B, \tag{A15}
$$

where:

$$h^B \equiv \frac{1-q_0^M}{1-\bar{q}} \frac{\omega+(1-\bar{q})(1-\omega)\beta_0^*}{\omega+(1-q_0^M)(1-\omega)\beta_0^*}, \quad \text{and} \quad h^N = \frac{q_0^M}{\bar{q}}. \tag{A16}$$

By implicit function differentiation of (A14), we obtain that $\partial q_0^{M*}/\partial \rho_0 = -(\partial H/\partial \rho_0)/(\partial H/\partial q_0^M)$, with $\partial H/\partial q_0^M < 0$, by the second-order conditions. Hence, we obtain that $\partial q_0^{M*}/\partial \rho_0 > 0$ if:

$$(1-\omega)\beta_0^* \left(\frac{\partial V_{H1}^N}{\partial \rho_1^N} \frac{\partial \rho_1^N}{\partial \rho_0} - \frac{\partial V_{H1}^B}{\partial \rho_1^B} \frac{\partial \rho_1^B}{\partial \rho_0} - \frac{\partial V_{H0}}{\partial \rho_0} \right) > 0. \tag{A17}$$

Note then that for $\rho \to 0$, we have that $\partial V_{H0}/\partial \rho_0 = \partial V_{H1}^G/\partial \rho_1^G = \partial V_{H1}^B/\partial \rho_1^B > 0$. Hence, there is a $\hat{\rho} > 0$ such that $\partial q_0^{M*}/\partial \rho_0$ is positive if $\rho_0 < \hat{\rho}$ and:

$$\frac{1}{h^N} - \frac{1}{h^B} - 1 > 0, \tag{A18}$$

or, from (A16), if:

$$\frac{\bar{q}}{q_0^M} - \frac{(1-\bar{q})(\omega+(1-q_0^M)(1-\omega)\beta_0^*)}{(1-q_0^M)(\omega+(1-\bar{q})(1-\omega)\beta_0^*)} > 1. \tag{A19}$$

This implies that there is a $\{\hat{\rho}, \hat{q}\}$ such that for $\bar{q} > \hat{q}$, and $\rho < \hat{\rho}$, inequality (A19) is satisfied, and $\partial q_0^{M*}/\partial \rho_0 > 0$. QED

Proof of Proposition 9. In the proposed equilibrium, firms first approach the high-reputation exchange Y, and, if rejected, the low-reputation exchange X. Hence, the ex-ante probability that a firm is good for the high-reputation exchange is ω, while, for the low-reputation exchange now is:

$$\omega^X(q_0^{Y*}) = \frac{(1-\eta)\omega\rho_0^Y}{(1-\eta)\omega+(1+\bar{q}-\eta)(1-\omega)} + \frac{(1-\eta)\omega(1-\rho_0^Y)}{(1-\eta)\omega+(1+q_0^{Y*}-\eta)(1-\omega} \tag{A20}$$

where q_0^{Y*} is the choice of standards by exchange Y. Given (A20) and $\omega^X < \omega$, it is optimal for a firm to seek listing with the high-reputation exchange Y first, and then, if rejected, apply to the low-reputation one. Hence,

a value maximizing exchange with high reputation, E = Y, will choose q_0^{MY} so as to maximize again (21). Conversely, a value maximizing exchange with low reputation, E = X, will choose q_0^{MX} so as to maximize (24), given (A20). By implicit function differentiation with respect to ω of the first order condition of (24), and by following a procedure similar to the one adopted in the proof of Proposition 8, we obtain that for $\omega \to 0$ we have that $\partial q_0^{X*}/\partial\omega > 0$. Hence, from Proposition 8, $\rho_0^Y > \rho_0^X$ implies that $q_0^{Y*} > q_0^{X*}$. QED

Proof of Proposition 10. If the number of low-cost investors in the two exchanges is the same, $N_\ell^X = N_\ell^Y$, and firms will approach first the high reputation exchange Y. Hence, this exchange will set the standards q_0^{Y*} as if it were a monopolist, giving (i). To see (ii), note first that, from (A20), we have that $\omega^X(q_0^{Y*}) < \omega$. From implicit function differentiation of the first order condition of (24), it may immediately be verified that for $\omega \to 0$, we have that $\partial q_0^{X*}/\partial\omega > 0$. This implies that there is a $\hat{\omega} > 0$ such that for $\omega < \hat{\omega}$ we have that $q_0^{X*}(\omega^X(q_0^{Y*})) < q_0^{X*}(\omega)$. QED

Proof of Proposition 11. If $N_\ell^Y < \bar{\mathbf{N}}_\ell^Y$ and $N_\ell^X > \bar{\mathbf{N}}_\ell^X$, then low-cost investors are marginal in the low reputation exchange X, and high-cost investors are marginal in the high reputation exchange Y. Furthermore, since, from (16), listing fees F_0 are proportional to firm value, a firm will choose first that exchange with higher V_{H0}. Consider then (i). In this proposed equilibrium, firms will go first to the low-reputation exchange X and, if rejected, to the high-reputation exchange Y. From Proposition 10, this implies that exchange X will set $q_0^{Xc} = q_0^{Xm}$ and exchange Y will instead set $q_0^{Yc} < q_0^{Ym}$. This sequential choice of exchanges is an optimal strategy if $V_{H0}^X > V_{H0}^Y$. Consider now $\hat{\rho}_1$, implicitly defined by $V_{H0}^X[\rho_0^X; \omega] = V_{H0}^Y[\hat{\rho}_1, \omega^Y(q_0^{X*})]$, where $\omega^Y(q_0^{X*})$ is defined in a way similar to (A20). Hence, from Propositions 9 and 10, we have that for $\rho_0^Y < \rho_1 \equiv \min\{\hat{\boldsymbol{\rho}}, \hat{\rho}_1\}$ we have that $V_{H0}^X > V_{H0}^Y$, and it is indeed optimal for a firm to go to the low-reputation exchange X first. Part (ii) is proved in a similar way, by setting now $\rho_0^Y > \rho_2$, where ρ_2 is implicitly defined by $V_{H0}^X[\rho_0^X; \omega^X(q_0^{Y*})] = V_{H0}^Y[\hat{\rho}_2, \omega]$. QED

Proof of Proposition 12. If $N_\ell^Y \geq N_\ell^{XZ}$, then listing on exchange Y will strictly dominate listing on the merged exchange XZ. If, instead, $N_\ell^Y \geq N_\ell^{XZ}$, then listing on the merged exchange XZ dominates listing on exchange Y if and only if low cost investors are marginal information producers only if the firm lists on exchange XZ, and the transparency of exchange Y is not too high. That is when $N_\ell^Y < \bar{\mathbf{N}}_\ell^Y$, $N_\ell^{XY} \geq \bar{\mathbf{N}}_\ell^{XY}$ and $\gamma^Y < \hat{\gamma}^Y$, where $\hat{\gamma}^Y$ is implicitly defined by $n_H^{*Y}(\hat{\gamma}^Y) = n_H^{*X}(\gamma^{XY})$. QED

Proof of Proposition 13. This proof follows an argument similar to one adopted in the proof of Proposition

11. (A) If $N_{\ell}^{XY} \leq N_{\ell}^{Y}$, then a firm will seek listing first on the high reputation exchange Y and, if rejected, on the merged exchange XZ. Therefore, this part of the proposition follows from Proposition 11. (B) If $N_{\ell}^{XY} > N_{\ell}^{Y}$, $N_{\ell}^{Y} < \bar{\mathbf{N}}_{\ell}^{Y}$, and $N_{\ell}^{XZ} \geq \bar{\mathbf{N}}_{\ell}^{XZ}$ then a firm will seek listing on the merged exchange XZ if the difference in reputation of the two exchanges is not too large. Thus, let $\tilde{\rho}_3$ be implicitly defined by $V_{H0}^{XZ}[\rho_0^{XZ}; \omega] = V_{H0}^{Y}[\tilde{\rho}_3, \omega^{Y}(q_0^{XZ*})]$, where $\omega^{Y}(q_0^{XZ*})$ is defined in a way similar to (A20). Hence, from Propositions 9 and 10 we have that for $\rho_0^{Y} < \rho_3 \equiv \min\{\hat{\boldsymbol{\rho}}, \tilde{\rho}_3\}$ we have that $V_{H0}^{XZ} > V_{H0}^{Y}$, and it is indeed optimal for a firm to go to the low-reputation exchange XZ first. Also, if $\rho^{XZ} = \max\{\rho^{X}, \rho^{Z}\}$, then the reputation of the merged exchange is as high as the reputation of each one of the individual exchanges before merging. In this case, after merging, Proposition 9 and 10 together imply again that $q_0^{XZc} > \max\{q_0^{Xc}; q_0^{Zc}\}$ (note that this possibly will arise, for instance, when $\rho^{X} = \rho^{Z}$). This implies that there is a $\tilde{\rho}^{XZ}$ such that $q_0^{XZc} > \max\{q_0^{Xc}; q_0^{Zc}\}$ for all $\tilde{\rho}^{XZ} < \rho^{XZ} < \max\{\rho^{X}, \rho^{Z}\}$ as well. QED