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Stock price informativeness, cross-listings, and investment decisions ☆

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Abstract

We show that a cross-listing enables firms to obtain, from the stock market, more precise information about the value of their growth opportunities. Thus, cross-listed firms make better investment decisions and trade at a premium. This theory of cross-listings implies that the sensitivity of investment to stock prices is larger for cross-listed firms. Moreover, the cross-listing premium is positively related to the size of growth opportunities and negatively related to the quality of managerial information. The sensitivity of the premium to the size of growth opportunities increases with factors that strengthen the impact of the cross-listing on price informativeness.

JEL classification: G14; G15; G39

Keywords: Cross-listings; Cross-listing premium; Price informativeness; Investment

1. Introduction

Multiple listings of firms on several exchanges are an enduring phenomenon that can be traced back to the 18th century (Sylla, Wilson, and Wright, 2006; Gehrig and Fohlin, 2006). Surprisingly, cross-listings thrive even as international financial markets become more integrated. Indeed, in the last decade, the number of cross-listed firms on U.S. markets has more than doubled (Karolyi, 2006) and some U.S. firms now have

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dual-listings on Nasdaq and the NYSE. Yet, the determinants and effects of the decision to cross-list are not fully understood (see Karolyi, 2006 for a survey), despite its importance for firms, market integration, and financial centers.[1]

In this paper, we propose a new explanation for this practice. We show that a cross-listing enables firms to obtain, from the stock market, more precise information about the value of their growth opportunities. This information enhances firm value as it helps managers to make better investment decisions. There is growing evidence supporting the hypothesis that managerial decisions rely in part on the information conveyed by stock prices (see Jegadeesh, Weinstein, and Welch, 1993; Markovitch, Steckel, and Yeung, 2005; Luo, 2005; Chen, Goldstein, and Jiang, 2007; Bakke and Whited, 2006).[2] It is therefore important to further study the implications of this hypothesis for corporate decisions, as we do here. Our analysis yields new testable predictions about the factors affecting the decision to cross-list, the effect of a cross-listing on firm value, and the linkage between investment and stock price for cross-listed firms.

There exist many other explanations for cross-listings (see Karolyi, 2006). Briefly, firms could cross-list to (i) avoid investment barriers (‘‘segmentation hypothesis’’), (ii) increase their visibility (‘‘recognition hypothesis’’), (iii) enhance their liquidity, (iv) signal their quality, and (v) commit to restrain expropriation by controlling shareholders (‘‘bonding hypothesis’’). Our model does not rule out these explanations. Rather it describes another mechanism through which a cross-listing could affect a firm value, which we call the ‘‘information channel.’’

We model the information channel in a standard model of multi-market trading (Chowdry and Nanda, 1991). In our model, managers have imperfect information on the value of their investment opportunities and learn additional information from their stock price. A cross-listing strengthens the informativeness of the stock price about future cash-flows, as found empirically by Fernandes and Ferreira (2005), because it expands the number of price signals about the firm and it increases traders' incentives to acquire information. Thus, other things equal, managers of cross-listed firms have more precise information about the value of their growth opportunities. Hence, they can more efficiently scale up or down the amount invested in these opportunities. A cross-listing intensifies informed trading, however. For this reason, it results in a larger wealth transfer from liquidity traders to informed traders. Accordingly, shareholders require a larger gross return to invest in a cross-listed firm.

Thus, the cross-listing decision involves a balancing act between the prospect of higher expected cash-flows and a greater cost of capital.[3] Two factors determine this decision for a firm: (i) the size of its growth opportunities and (ii) the quality of its manager's information about these opportunities. Firms with larger growth opportunities benefit relatively more from a cross-listing and therefore are more likely to cross-list, as found empirically (see, for instance, Pagano, Roëll, and Zechner, 2002). Firms with well informed managers are less likely to cross-list because they rely less on stock price information.

In our model, the average value of a cross-listed firm is greater than that of a non cross-listed firm because firms optimally cross-list when they have sufficiently large growth opportunities. Thus, the model implies the existence of a *cross-listing premium*. This implication is important as several researchers document such a premium for firms cross-listed in the U.S. (e.g., Doidge, Karolyi, and Stulz, 2004; Gozzi, Levine, and Schmukler, 2005; King and Segal, 2006). We also show that the cross-listing premium persists when we control for the size of growth opportunities (that is, when we compare the value of a given cross-listed firm with its value if it were not cross-listed). The reason is that a cross-listed firm exploits more efficiently its growth opportunities as its manager benefits from a more informative stock price. This implication is also consistent with the empirical findings in Doidge, Karolyi, and Stulz (2004).

Doidge, Karolyi, and Stulz (2004) argue that the cross-listing premium reflects more stringent governance regulations in the U.S. Our theory shows that this premium could also stem from an improvement in stock

[1] For the impact of cross-listings on financial development, see the ‘‘Interim Report of the Committee on Capital Markets Regulation,’’ November 2006.

[2] For instance, Luo (2005) finds empirically that merger plans are more likely to be canceled when the bidder and the target experience abnormal negative returns after the merger announcement. He shows that managerial learning from stock price reaction is the most plausible explanation for this finding.

[3] In most theories of cross-listings (e.g., those based on the segmentation or the recognition hypotheses), a cross-listing has no effect on a firm's expected cash-flows.

price informativeness. Specifically, the model implies that the *sensitivity* of the cross-listing premium to the size of growth opportunities should be (i) positive, (ii) inversely related to the quality of managerial information, and (iii) positively related to factors that strengthen the impact of a cross-listing on stock price informativeness. The fraction of total liquidity demand due to shareholders who exclusively trade in their home market is one such factor. Actually, when this fraction enlarges, the price innovations in the foreign and the domestic market are less correlated and, therefore, more informative. The two last predictions are specific to our theory and could be used to assess the empirical importance of the information channel for the cross-listing premium.

Recent studies (e.g., Halling, Pagano, Randl, and Zechner, 2005) document cross-sectional variations in the volume share of the foreign market for cross-listed firms. In our model, the informational benefit of a cross-listing is higher when trading is more evenly distributed between the foreign and the domestic market. However, in this case, trading costs for liquidity traders are greater because trading is more fragmented. For these reasons, the cross-listing premium and the volume share of the foreign market are correlated but the sign of this correlation can be positive or negative. We show that it is more likely to be positive for firms with large growth opportunities. The empirical literature also finds that for some cross-listed stocks, trading concentrates in the domestic market, which questions the benefit of a cross-listing in this case. Interestingly, we find that the cross-listing premium persists when trading predominantly occurs in only one market. Actually, in this case, a cross-listing enhances stock price informativeness by expanding the number of price signals about the firm, even if its impact on the number of informed traders becomes negligible.

Last, the model implies that the sensitivity of investment to stock price, for a given firm, should increase after a cross-listing. Indeed, after a cross-listing, the stock price is more informative. Hence, it more heavily influences a manager's expectation about the value of the growth opportunities for her firm and, therefore, her investment choices. This prediction offers a sharp way to test our model because it does not follow from other theories of cross-listings.

In our model, a cross-listing improves investment decisions inasmuch as managers do not possess perfect information on the payoffs of their growth opportunities. Nevertheless, the information channel could also drive cross-listing decisions even when managers are very well informed for two reasons. First, as formalized by Holmström and Tirole (1993), a more informative stock market helps to design better incentives packages for managers. Second, stock price information can ease financing of new projects as it helps fund providers to learn about the value of a firm's projects, as found empirically by Sunder (2002).

There is a vast empirical literature on cross-listings but relatively few theoretical analyses. In general, theories of cross-listings do not explicitly model the decision to cross-list as we do here. Fuerst (1998) and Chemmanur and Fulghieri (2006) are exceptions.[4] In contrast to these authors, we assume that firms' managers are not perfectly informed about the value of their growth opportunities and learn additional information from the stock market. Our model also contributes to the growing literature on investment decisions when managers use stock price information (e.g., Khanna, Slezak, and Bradley, 1994; Boot and Thakor, 1997; Dow and Gorton, 1997; Subrahmanyam and Titman, 1999; or Dow, Goldstein, and Guembel, 2006). In particular, it adds the possibility of a dual-listing in Subrahmanyam and Titman's (1999) theory of the going public decision.

Section 2 presents a model of cross-listings. Section 3 analyzes the cost and benefit of a cross-listing in this model. Section 4 derives the testable implications. Section 5 concludes. Proofs are in the appendices.

2. Model

The model has four stages as shown in Fig. 1.

[4]Other papers analyze cross-border trading (Gehrig, Stahl, and Vives, 1996; Biais and Martinez, 2004; Baruch, Karolyi, and Lemmon, 2006) or the choice of a listing location (Foucault and Parlour, 2004; Baruch and Saar, 2006) but do not study the decision to cross-list.

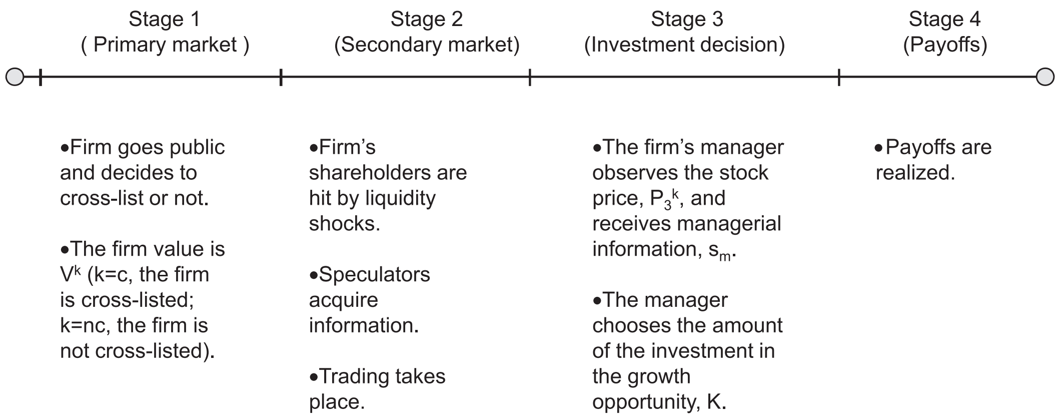

Fig. 1. Timing.

2.1. The firm

Following Subrahmanyam and Titman (1999) (henceforth ST, 1999), we consider a firm with assets in place and a growth opportunity. The payoff of the assets in place, $\widetilde{V}$, is

$$\widetilde{V} = \overline{V} + \tilde{\delta}, \tag{1}$$

where $\tilde{\delta}$ is normally distributed with mean 0 and variance σ_δ^2. The payoff of the growth opportunity, $G(K, \widetilde{\theta})$, is

$$G(K, \widetilde{\theta}) = S((K_0 + \widetilde{\theta})K - 0.5K^2), \tag{2}$$

where K is the amount of the investment in the growth opportunity and S is a scale factor. As we shall see later, K_0 is the amount invested in the growth opportunity when a manager has no information. The value of the growth opportunity is uncertain as $\widetilde{\theta}$ is normally distributed, with mean zero and variance σ_θ^2. Moreover

$$\tilde{\delta} = (\gamma)^{1/2}\widetilde{\theta} + (1-\gamma)^{1/2}\widetilde{\kappa}, \tag{3}$$

where $\widetilde{\kappa}$ and $\widetilde{\theta}$ are independently distributed, $\gamma > 0$ and $\sigma_\theta^2 = \sigma_\kappa^2$.[5] Thus, the correlation between the payoffs of the growth opportunity and the asset in place is $(\gamma)^{1/2}$. All payoffs are realized in Stage 4.

In Stage 1, the firm goes public and the manager chooses to list on the home market of the firm (exchange L) only or to dual-list on the home market and the foreign market (exchange F). ST (1999) provide a complete analysis of the choice between public and private financing in the setting considered in this paper (with $\gamma = 1$). Thus, for brevity, we take as given that the firm wants to be publicly listed and we focus exclusively on the cross-listing decision.

The realized values of $\tilde{\delta}$ and $\widetilde{\theta}$, are unknown to the firm's manager. In Stage 3, she obtains imperfect information on $\widetilde{\theta}$ from two sources: (i) the stock price of the firm at this stage, P_3 and (ii) a signal, $\widetilde{s}_m$ ("*managerial information*"), such that

$$\widetilde{s}_m = \widetilde{\theta} + \widetilde{m}, \tag{4}$$

where $\widetilde{m}$ is normally distributed with mean zero and variance σ_m^2. Given these signals, the manager chooses the investment in the growth opportunity, $K^*(\widetilde{s}_m, P_3)$. The expected value of the growth opportunity in Stage 1 (given optimal investment decisions in Stage 3) is $EG^k \stackrel{def}{=} E(G(K^*(\widetilde{s}_m, P_3), \widetilde{\theta}))$ ($k = c$ if the firm is cross-listed and $k = nc$ if it is not).

Listing and investment decisions are chosen to maximize the expected value of the firm. Investors who buy shares of the firm in Stage 1 discount their valuation for the firm by the size of their expected trading cost in the secondary market, as in Holmström and Tirole (1993) or ST (1999). We call this discount the *illiquidity premium* and we denote it T^c (resp. T^{nc}) when the firm is cross-listed (resp. not cross-listed). Hence, in Stage 1,

[5] The condition $\sigma_\kappa^2 = \sigma_\theta^2$ implies $\sigma_\theta^2 = \sigma_\delta^2$. In this way, the correlation between the payoff of the growth opportunity and the payoff of the asset in place is independent of the uncertainty on the payoffs of the asset in place and the growth opportunity.

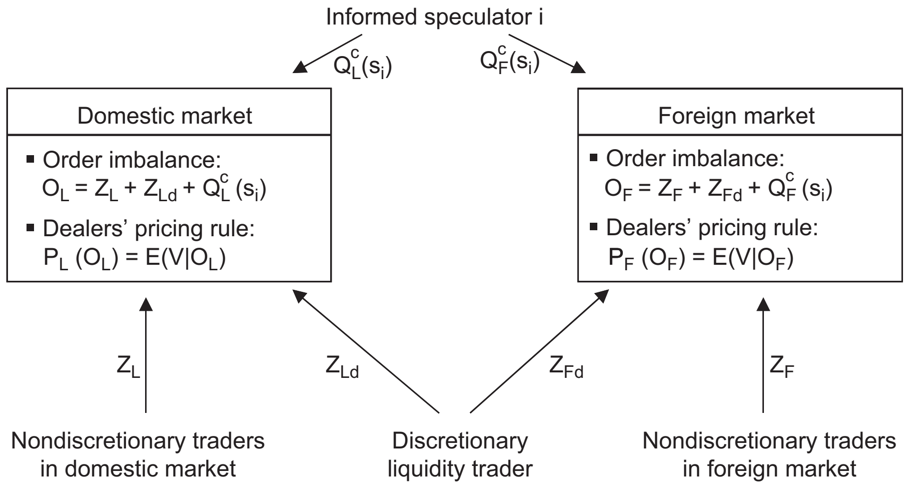

Fig. 2. Participants in the stock market when the firm is cross-listed. Nondiscretionary traders trade only in their home market. Their aggregate order size in the domestic market is Z_L and their aggregate order size in the foreign market is Z_F. The discretionary liquidity trader must trade Zd shares but can fill this order by submitting orders in both the domestic market and the foreign market. His order size in the domestic market is Z_{Ld} and his order size in the foreign market is Z_{Fd} ($Z_d = Z_{Ld} + Z_{Fd}$). These orders are chosen to minimize his expected trading loss. An informed speculator receives a signal s_i and can submit market orders in both markets. Informed speculator i's order in market j is denoted $Q_j^c(s_i)$. His order in each market is chosen to maximize his expected profit. Prices in each market are set by risk-neutral dealers after observing the net order imbalance in their market.

the expected value of the firm in regime k, V^k, is

$$V^k \overset{def}{=} \overline{V} + EG^k - T^k, \quad k \in \{c, nc\}. \tag{5}$$

As in ST (1999), we assume that the firm shares are claims on the cash-flows of the assets in place but not on the cash-flows of the growth opportunity.[6] This assumption is necessary for tractability. Indeed, in our model, the investment in the growth opportunity depends on the stock price in Stage 3. In turn, if the stock is a claim on the growth opportunity, the stock price in Stage 3 also depends on the investment in the growth opportunity. This loop ("the stock price affects investment that affects the stock price") creates a fixed-point problem that considerably complicates the analysis and precludes closed-form solutions in the normal Gaussian environment. The ST's (1999) approach mutes the feedback of investment onto stock price, which simplifies the analysis. This simplification is not key for our results because they only derive from the impact of price on investment. We have checked, under simpler parametric assumptions (a binary distribution for $\widetilde{\delta}$), that the implications of the model are still valid when the firm share is a claim on both the assets in place and the growth opportunity.[7]

2.2. The stock market

In Stage 2, a secondary market for the firm's shares is open, in exchange L and, if the firm is dually listed, in exchange F as well. Secondary market trading is modeled as in Chowdry and Nanda (1991). There are four categories of risk neutral traders: (i) *speculators*, (ii) *discretionary liquidity traders*, (iii) *nondiscretionary liquidity traders*, and (iv) *dealers*. They differ in their access to information, cross exchange resource mobility, and objective functions, as explained below and shown in Fig. 2.

Speculators: Each speculator can, at a cost C, acquire a signal on the final payoff of the asset in place. Specifically, if he buys information, speculator i observes a signal, $\widetilde{s}_i$ such that

$$\widetilde{s}_i = \widetilde{\delta} + \widetilde{\varepsilon}_i. \tag{6}$$

[6] The firm can be seen as a holding with two distinct (a public and a private) subsidiaries. Managers learn information from the stock price of the publicly traded subsidiary and use it for investment decisions in the privately owned subsidiary.

[7] This robustness check can be obtained from the authors upon request.

Signals are heterogeneous and the ε_is are independently and normally distributed with mean zero and variance σ_ε^2. Speculators with information submit market orders in the foreign market and the domestic market to maximize their total expected profits. They represent, for instance, institutions or hedge funds that have paid the set-up costs required for multi-market trading (e.g., they have accounts with the clearing and settlement systems of each market). Speculators who do not buy information abstain from trading. In regime $k \in \{c, nc\}$, we denote by M^k, the number of speculators buying information and by $Q_j^k(s_i)$, the size of the market order submitted in exchange j by speculator i.

Liquidity traders: Liquidity traders are shareholders of the firm who must buy or sell a fixed number of shares because they are hit by liquidity shocks. Nondiscretionary liquidity traders trade only in their home market. They represent retail investors, who generally do not have the infrastructure required for multi-market trading, or institutions that face prudential constraints on their holdings of foreign stocks. In contrast, discretionary liquidity traders can trade in both foreign and domestic markets. Thus, they allocate their liquidity demand between the two markets to minimize their expected trading losses (that arise from illiquidity—see below). Without affecting the results, we assume that there is a single discretionary liquidity trader.

We denote by $\tilde{Z}_j$, the aggregate liquidity demand of nondiscretionary traders based in country $j \in \{L, F\}$, by $\tilde{Z}_d$, the discretionary trader's aggregate liquidity demand, and by $\tilde{Z}_{jd}$, the size of the discretionary trader's order in country j ($\tilde{Z}_d = \tilde{Z}_{Ld} + \tilde{Z}_{Fd}$). Hence, aggregate liquidity demand, $\tilde{Z}$, is

$$\tilde{Z} = \tilde{Z}_L + \tilde{Z}_F + \tilde{Z}_d. \tag{7}$$

Liquidity demands are normally and independently distributed with mean zero. The variance of $\tilde{Z}_j$ is denoted σ_j^2 and the variance of $\tilde{Z}$ when the firm is cross-listed is denoted σ_Z^{2c}. The average size of liquidity demand by investors of category $j \in \{L, F, d\}$ is determined by σ_j^2 (since $E(\tilde{Z}_j^2) = \sigma_j^2$). The aggregate amount of liquidity trading, σ_Z^{2c}, is split among the various categories of liquidity traders as follows

$$\sigma_L^2 = a_L \sigma_Z^{2c}, \tag{8}$$

$$\sigma_F^2 = a_F \sigma_Z^{2c}, \tag{9}$$

$$\sigma_d^2 = a_d \sigma_Z^{2c}, \tag{10}$$

with $a_L + a_F + a_d = 1$. We set $a_L + a_F = \phi$ and $a_d = (1 - \phi)$. Moreover, we set $a_L = \alpha\phi$ and $a_F = (1 - \alpha)\phi$. Thus, parameter ϕ determines the breakdown of total liquidity demand between nondiscretionary and discretionary liquidity traders while α determines the breakdown of nondiscretionary liquidity demand between domestic and foreign nondiscretionary liquidity traders. When ϕ increases, nondiscretionary liquidity demand accounts for a larger share of total liquidity demand. When α increases, nondiscretionary liquidity traders in country L account for a larger share of total nondiscretionary liquidity demand.

In the model, the effect of a cross-listing depends on the level of concentration of nondiscretionary liquidity demand in one market. For this reason, we define $i(\alpha) \overset{def}{=} |\alpha - 50\%|$, which is a measure of the geographical concentration of nondiscretionary liquidity demand. Indeed, as $i(\alpha)$ increases, nondiscretionary liquidity demand increasingly concentrates in either the domestic market or the foreign market. *For cross-listed firms*, we refer to $(i(\alpha), \phi)$ as the *shareholding structure* since, in reality, the breakdown of total liquidity demand among various categories of shareholders is in part determined by the composition of its shareholder base. For instance, a firm with a large base of retail shareholders (or constrained institutions) after its cross-listing has a higher ϕ. Moreover, if domestic (resp. foreign) retail shareholders in the ownership prevail after the cross-listing then $\alpha > 50\%$ ($\alpha < 50\%$). Parameters ϕ and α are exogenous in the model.

If the firm is not cross-listed, then foreign nondiscretionary liquidity traders cannot invest in the firm, that is, $\alpha = 100\%$. We denote the aggregate liquidity demand in this case by σ_Z^{2nc}. Its split among various categories of shareholders plays no role when the firm has a single listing. We focus on the case in which $\sigma_Z^{2c} \geqslant \sigma_Z^{2nc}$ because, usually, a cross-listing expands a firm's shareholder base and, therefore, the amount of liquidity trading. But, the analysis encompasses the particular case in which a cross-listing does not affect the total amount of liquidity trading (i.e., $\sigma_Z^{2c} = \sigma_Z^{2nc}$).

The Dealers: Dealers in each market post quotes at which they absorb the net order imbalance in their market. We denote the net order imbalance in market j by O_j (that is, $O_j = Z_j + Z_{jd} + \sum_{i=1}^{i=M^k} Q_j^k(s_i)$). Competition implies that dealers earn zero expected profits. That is, dealers in market j absorb the net order imbalance in this market at price

$$P_j(O_j) = E(\tilde{V}|\tilde{O}_j = O_j), \quad j \in \{L, F\}. \tag{11}$$

Order imbalances in markets L and F are not identical because nondiscretionary liquidity traders' demands are independent across markets. Thus, in the trading round, transaction prices differ in the home market and the foreign market. Hupperets and Menkveld (2002) and Eun and Sabherwal (2003) document such price differentials for cross-listed stocks and show that they quickly disappear as dealers in one market get quote and trade information from the competing market. The price at the beginning of Stage 3 reflects the information contained in price innovations in each market and is given by

$$P_3^k = E(\widetilde{V}|\Omega^k), \quad \text{for } k \in \{c, nc\}, \tag{12}$$

where $\Omega^c = \{P_L^c, P_F^c\}$ and $\Omega^{nc} = \{P_L^{nc}\}$.[8]

3. The cross-listing decision

In this section, we study the costs and benefits of a cross-listing in our model. We proceed as follows. First, in Section 3.1, we derive the equilibrium of the stock market for a given listing choice of the firm. Then, in Section 3.2, we study the optimal investment in the growth opportunity in Stage 3. We show that the expected value of this growth opportunity is larger when the firm is cross-listed because the stock market is more informative in this case. We also show that a cross-listing results in larger expected trading costs for liquidity traders. Thus, the cross-listing decision involves a trade-off between a more efficient investment decision and a larger illiquidity premium. We study the testable implications of this trade-off in Section 4.

3.1. Stock market equilibrium with and without a cross-listing

We first describe the equilibrium of the stock market, for a given number of informed investors, when the firm is cross-listed and when it is not. We denote by ρ_ε, the signal-to-noise ratio $(\sigma_\delta^2/\sigma_\delta^2 + \sigma_\varepsilon^2)$. The smaller is ρ_ε, the lower the precision of each speculator's signal and the greater the dispersion of speculators' signals.

Lemma 1.

- *In equilibrium, when the firm is cross-listed, dealers' price in market j is*

  $$P_j(O_j) = \overline{V} + \lambda_j^*(\alpha)O_j \quad \textit{for } j \in \{L, F\}.$$

  The discretionary liquidity trader's optimal market order in market j is

  $$Z_{jd} = \omega_j^*(\alpha)Z_d, \quad \textit{for } j \in \{L, F\},$$

  and speculator i's optimal market order in market j is

  $$Q_j^c(s_i) = \beta_j^*(\alpha)s_i, \quad \textit{for } j \in \{L, F\},\ i \in \{1, \ldots, M^c\},$$

  with $\lambda_j^*(\alpha) = \frac{\sqrt{M^c \rho_\varepsilon}}{(2+(M^c-1)\rho_\varepsilon)}\sqrt{\frac{\sigma_\delta^2}{(\omega_j^*(\alpha))^2\sigma_d^2+\sigma_j^2}}$, $\omega_j^*(\alpha) = \frac{\sigma_j}{\sigma_F+\sigma_L}$, *and* $\beta_j^*(\alpha) = \frac{\rho_\varepsilon}{(2+(M^c-1)\rho_\varepsilon)\lambda_j^*(\alpha)}$ *for* $j \in \{L, F\}$.

- *If the firm lists only in the domestic market, the equilibrium is as described above when* $\alpha = 1$, *substituting* M^{nc} *with* M^c *and* σ_Z^{2c} *with* σ_Z^{2nc} *in all formulae.*

[8] Stage 3 must be interpreted as the future point in time at which the firm plans to make its investment decision. For simplicity, however, in Stage 2, there is a single trading round, construed as a reduced form for multiple days with different generations of speculators endowed with different signals as in Vives (1995). In this case, dealers would learn innovations in the competing markets at the end of each trading round.

This result is a straightforward extension of Lemma 1 in Chowdry and Nanda (1991) (they focus on the case $M^c = M^{nc} = 1$ and $\rho_\varepsilon = 1$). Hence, we skip its derivation for brevity (the proof can be obtained from the authors upon request).

The equilibrium has the following properties. First, the market with the largest proportion of nondiscretionary liquidity traders is deeper.[9] Indeed

$$\frac{\lambda_F^*(\alpha)}{\lambda_L^*(\alpha)} = \frac{\sigma_L}{\sigma_F} = \sqrt{\frac{\alpha}{1-\alpha}} > 1 \text{ iff } \alpha > \frac{1}{2}.$$

Second, to minimize price impact, speculators and the discretionary liquidity traders split their orders between the two markets and trade relatively more in the deeper market (since $\omega_L^*/\omega_F^* = \beta_L^*/\beta_F^* = \lambda_F^*/\lambda_L^*$). Third, the distribution of trading activity between the two markets is determined by α. Indeed, the absolute trade sizes of both speculators and liquidity traders are larger in the domestic (resp. foreign) market if $\alpha > \frac{1}{2}$ (resp. $\alpha < \frac{1}{2}$).[10] Thus, trading concentrates in the domestic (resp. foreign) market as α goes to one (resp. zero) and markets have equal market shares (in terms of trading volume) if and only if $\alpha = 0.5$.

Let $T_j^c(M^c; \alpha, \phi, \sigma_Z^{2c})$ be the aggregate expected trading losses for liquidity traders of category $j \in \{L, F, d\}$ when the firm is cross-listed. The illiquidity premium for a cross-listed firm is

$$\begin{aligned} T^c(M^c; \alpha, \phi, \sigma_Z^{2c}) &= \sum_{j \in \{L,F,d\}} T_j(M^c; \alpha, \phi, \sigma_Z^{2c}) \\ &= \sum_{j \in \{L,F\}} E((P_j - \tilde{V})\tilde{Z}_j) + \sum_{j \in \{L,F\}} E((P_j - \tilde{V})\tilde{Z}_{jd}), \end{aligned}$$

which, using Lemma 1, implies

$$T^c(M^c; \alpha, \phi, \sigma_Z^{2c}) = \lambda_L^* \sigma_L^2 + \lambda_F^* \sigma_F^2 + (\lambda_L^* {\omega_L^*}^2 + \lambda_F^* {\omega_F^*}^2)\sigma_d^2. \tag{13}$$

As dealers break even, informed traders' aggregate expected profit, $\Pi^c(M^c; \alpha, \phi, \sigma_Z^{2c})$, is equal to liquidity traders' aggregate expected losses, T^c, that is,

$$\Pi^c(M^c; \alpha, \phi, \sigma_Z^{2c}) = T^c(M^c; \alpha, \phi, \sigma_Z^{2c}) \tag{14}$$

$$= \frac{\sqrt{M^c \rho_\varepsilon}}{(2 + (M^c - 1)\rho_\varepsilon)} \left(\sqrt{(2\phi\sqrt{\alpha(1-\alpha)} + 1)\sigma_\delta^2 \sigma_Z^{2c}} \right), \tag{15}$$

where the second equality follows from Eq. (13) and Lemma 1. When the firm is not cross-listed then $\alpha = 1$ and the number of informed traders is M^{nc}. Thus, in this case, the illiquidity premium, T^{nc}, and informed traders' aggregate expected profit, Π^{nc}, are

$$T^{nc} = \Pi^{nc} = \Pi^c(M^{nc}; 1, \phi, \sigma_Z^{2nc}) = \frac{\sqrt{M^{nc}\rho_\varepsilon}}{(2 + (M^{nc} - 1)\rho_\varepsilon)} \left(\sqrt{\sigma_\delta^2 \sigma_Z^{2nc}} \right). \tag{16}$$

In either case, the equilibrium number of informed investors, M^{k*}, is such that an informed trader's expected profit is equal to the cost of information, C (ignoring the integer problem to simplify). Thus, the number of informed investors solves

$$\Pi^k(M^{k*}; \alpha^k, \phi, \sigma_Z^{2k})/M^{k*} = C, \quad \text{for } k \in \{c, nc\}, \tag{17}$$

with $\alpha^{nc} = 1$ and $\alpha^c = \alpha$.

Lemma 2.

- *The number of informed traders is larger when the firm is cross-listed than when it lists only in the domestic market (i.e., $M^{c*} > M^{nc*}$).*

[9] As in Kyle (1985), λ_j is a measure of the depth of market j since it determines the price impact of a buy or sell order. The smaller is λ_j, the larger the depth of market j.

[10] For instance, the absolute trade size of the discretionary liquidity trader in market j is given by $|Z_{jd}| = \omega_j^*(\alpha)|Z_d|$. Thus, $|Z_{Ld}| > |Z_{Fd}|$ if and only if $\omega_j^*(\alpha) > 1/2$, that is, if and only if $\alpha > 1/2$ (from the expression for $\omega_j^*(\alpha)$ in Lemma 1).

- *Moreover, when the firm is cross-listed, the number of informed traders depends on the shareholding structure of the firm*: (i) *it decreases in* $i(\alpha)$ *and* (ii) *it increases in* ϕ.

A cross-listing opens new profit opportunities for informed traders. Indeed, they can exploit their private information twice by trading both in the foreign market and in the domestic market. Thus, these traders obtain a larger aggregate expected profit than when the firm has a single listing. This effect triggers entry of additional informed traders when the firm dual-lists. Consistent with this result, Noronha, Sarin, and Saudagaran (1996) find that the level of informed trading increases for firms listed on NYSE and AMEX following their dual-listing on the London Stock Exchange.

The distribution of liquidity demands between the foreign market and the domestic market affects the equilibrium number of informed traders for the following reason. An informed trader's expected profit in a given market is proportional to the total liquidity demand in this market (measured by the standard deviation of liquidity demand). A shift in nondiscretionary liquidity demand from the foreign market to the domestic market (starting from $\alpha \geqslant 50\%$) increases the total liquidity demand in the domestic market and decreases it in the foreign market. But the first effect is smaller than the second because pooling liquidity demands diversifies liquidity shocks. This diversification effect is strengthened when the discretionary trader has a larger weight in total liquidity demand (ϕ small) as the latter trades more heavily in the market where nondiscretionary liquidity traders cluster. For these reasons, informed traders' total expected profit decreases when $i(\alpha)$ increases or ϕ decreases.

The stock price at the beginning of Stage 3, P_3^k is the expected payoff of the asset in place conditional on price innovations in Stage 2 (Eq. (12)). As these innovations are in part driven by informed trades, the stock price contains information on the stochastic component for the payoff of the assets in place, $\widetilde{\delta}$, and thereby on the value of the growth opportunity. Let us define: $I(P_3^k) \stackrel{def}{=} \sigma_\theta^2 - Var(\widetilde{\theta}|P_3^k)$. For a given regime (cross-listed/not cross-listed), this variable measures the informativeness of the stock price about the payoff of the growth opportunity. Indeed, the larger $I(P_3^k)$ is, the smaller the residual uncertainty on $\widetilde{\theta}$ after observing the stock price.

Proposition 3.

(1) *Price informativeness is strictly larger when the firm is cross-listed than when it is not*.
(2) *The* (*relative*) *improvement in price informativeness* (*i.e.*, $(I(P_3^c) - I(P_3^{nc}))/I(P_3^{nc})$) *due to a cross-listing is strictly larger than* $\phi/(2(M^{nc*} - 1)\rho_\varepsilon + 4 - \phi)$ *for* $\rho_\varepsilon > 0$. *Moreover, this improvement depends on the shareholding structure of the firm*: (i) *it decreases with* $i(\alpha)$ *and* (ii) *it increases in* ϕ.
(3) *Price volatility* ($Var(P_3^k - \overline{V})$) *is larger when the firm is cross-listed*.

A cross-listing enhances price informativeness for two reasons. First, it triggers entry of additional informed traders (Lemma 2). Second, price innovations provide distinct signals about the payoff of the assets in place because order imbalances in each market are not perfectly correlated (since trades by nondiscretionary investors are independent).[11] Thus, a cross-listing triggers a jump in price informativeness, even if its impact on the number of informed traders is negligible (α close to one or zero). As explained in Section 4, this finding implies that the impact of a cross-listing on firm value remains significant even when trading concentrates in one market. The size of the jump in price informativeness after a cross-listing enlarges when discretionary trading accounts for a smaller fraction of liquidity trading (ϕ increases). Indeed, this reduction weakens the correlation between cross-border price innovations and, therefore, makes their joint observation more informative.[12]

As the stock price reflects more information about the firm's payoff, it is more volatile, as stated in the last part of the proposition. This implication is consistent with empirical findings in Domowitz, Glen, and

[11] Menkveld (2007) studies a sample of stocks cross-listed in London and NYSE. For these stocks, he finds that the correlation in five-minute order imbalances across markets is less than 0.08 in most cases.

[12] The discretionary trader's orders are perfectly correlated across markets (see Lemma 1). Thus, they increase the covariation between domestic and foreign order imbalances.

Madhavan (1998) and Bailey, Karolyi, and Salva (2005). Interestingly, Domowitz, Glen, and Madhavan (1998) show that the increase in volatility after a cross-listing is unrelated to changes in liquidity and trading activity. They conclude that the change in volatility reflects a change in information structure, in line with the logic of our model. Fernandes and Ferreira (2005) use firm-specific stock return variation as a proxy for price informativeness (as initially suggested by Roll, 1988). For a large sample of firms cross-listed in the U.S., they show that a cross-listing improves this measure of price informativeness for firms from developed countries. This finding is consistent with Proposition 3 as well.

Proposition 3 (and all subsequent results) also hold if the number of informed traders is fixed exogenously.[13] In this case, price informativeness increases after a cross-listing because each speculator trades more aggressively on his signal when the firm is cross-listed and a cross-listing expands the number of price signals available to market participants.

3.2. Benefits and costs of cross-listings

In Stage 3, the manager chooses the size of the investment in the growth opportunity after observing the stock price, P_3^k and managerial private information, s_m.[14] Using Eq. (2), we deduce that the optimal investment in the growth opportunity is

$$K^*(s_m, P_3^k) = K_0 + E(\widetilde{\theta}|\widetilde{s}_m, P_3^k), \quad k \in \{c, nc\}. \tag{18}$$

Signals $\widetilde{s}_m$ and P_3^k are linear in $\widetilde{\theta}$ and independent, conditional on $\widetilde{\theta}$. Hence, normal theory implies that

$$K^*(s_m, P_3^k) = K_0 + \frac{\tau_m}{\tau_m + \tau_k} s_m + \frac{\tau_k\sqrt{\gamma}}{\tau_m + \tau_k}(P_3^k - \overline{V}), \tag{19}$$

where $\tau_m \equiv (\sigma_m^2)^{-1}$ (the precision of signal s_m) and $\tau_k \equiv (Var(\widetilde{\theta}|P_3^k))^{-1}$. The stock price is more likely to increase (relative to its mean value) when $\delta > 0$ than when $\delta < 0$. Indeed, in this case, informed traders are more likely to receive positive signals and to be, on average, net buyers of the stock. Thus, as $\gamma > 0$, the manager's expectation about the payoff of the growth opportunity, and thereby her investment in this growth opportunity, increases in the stock price. In absence of information ($s_m = 0$ and $P_3^k = \overline{V}$), the manager invests K_0. In the rest of the paper we normalize this baseline level of investment to zero, without affecting the results.

In Stage 1, the expected value of the growth opportunity is

$$EG^k = S * E\left(\widetilde{\theta}K^*(\widetilde{s}_m, P_3^k) - \frac{(K^*(\widetilde{s}_m, P_3^k))^2}{2}\right) \quad k \in \{c, nc\}. \tag{20}$$

Using Eq. (18), we deduce that

$$EG^k = \frac{S\,Var(E(\widetilde{\theta}|s_m, P_3^k))}{2} \quad k \in \{c, nc\}. \tag{21}$$

The greater $Var(E(\widetilde{\theta}|s_m, P_3^k))$ is, the greater the informativeness of the signals received by the manager in Stage 3.[15] We deduce the following result.

Lemma 4. *The expected value of the growth opportunity is*

$$EG^k = \frac{S}{2}\left(\frac{\sigma_\theta^4 + (\sigma_m^2 - \sigma_\theta^2)I(P_3^k)}{\sigma_m^2 + \sigma_\theta^2 - I(P_3^k)}\right) \quad \text{for } k \in \{c, nc\}. \tag{22}$$

It increases with the informativeness of the stock price, $I(P_3^k)$, if managerial information is imperfect (i.e., $\sigma_m^2 > 0$).

[13] This claim can be checked by replacing M^c by M^{nc} in all formulae.

[14] The findings are identical if the manager observes prices P_L^k and P_F^k because P_3^k is a sufficient statistic for $\{P_L^k, P_F^k\}$.

[15] When X and Y are normally distributed, $Var(Y|X) = Var(Y) - Var(E(Y|X))$ (even if X is multi-dimensional). Hence, the larger $Var(E(Y|X))$ is, the more precise the posterior of Y after observing X. Thus, $Var(E(Y|X))$ is a measure of the informational content of X about Y.

The intuition for this result is straightforward. A more informative stock price enables the manager to make an investment decision that is closer to the decision she would make if she had perfect information. Thus, it enhances the expected value of the growth opportunity. As the informativeness of the stock price is larger when the firm is cross-listed (Proposition 3), the expected value of the growth opportunity is larger in this case. We state this central result in the next proposition.

Proposition 5 (*benefit of a cross-listing*). *The expected value of the growth opportunity is larger when the firm is cross-listed, that is,* $\Delta EG \overset{def}{=} EG^c - EG^{nc} > 0$.

A cross-listing encourages information production by the stock market. Thus, it increases the expected value of the growth opportunity. But, it translates in larger aggregate expected trading losses (T^k) for liquidity traders. Indeed, as nondiscretionary liquidity traders' losses, T^k, are equal to aggregate informed traders' profits, Π^k, Eq. (17) yields

$$\Delta T \overset{def}{=} T^c - T^{nc} = \Pi^c(M^c; \alpha, \phi, \sigma_Z^{2c}) - \Pi^{nc} = (M^{c*} - M^{nc*})C > 0, \tag{23}$$

where the inequality follows from Lemma 2.[16] Thus, other things equal, the illiquidity premium, i.e., the compensation required by initial shareholders to buy shares of the firm, is larger when a firm cross-lists.

Proposition 6 (*cost of a cross-listing*). *The illiquidity premium is larger when the firm is cross-listed than when it is not. Furthermore, in equilibrium, the illiquidity premium of a cross-listed firm depends on its shareholding structure*: (i) *it decreases with* $i(\alpha)$ *and* (ii) *it increases with* ϕ.

Changes in the shareholding structure that intensify informed trading result in larger expected losses for liquidity traders. Thus, the illiquidity premium becomes smaller when discretionary traders hold a greater fraction of the issue or when nondiscretionary liquidity demand is more concentrated geographically.

In Stage 1, the firm decides to cross-list when its value is larger in this case, that is,

$$\Delta V \overset{def}{=} V^c - V^{nc} = \Delta EG - \Delta T > 0. \tag{24}$$

Thus, the firm cross-lists when the subsequent improvement in the expected value of future growth opportunities dominates the increase in illiquidity premium. Below, for cross-listed firms, we refer to ΔV as the *cross-listing premium*.

Stock market information is obtained at the cost of a wealth transfer from liquidity traders to informed investors. The manager could avoid this cost by collecting signals directly. When informed traders have heterogeneous signals ($\sigma_\varepsilon^2 > 0$), this approach is likely to be more costly than obtaining information from the stock market for two reasons. First, information processing costs imply a positive and highly convex relationship between the cost of information and the number of signals collected by a single individual (see ST, 1999; Holmström and Tirole, 1993). Second, hiring agents to collect information creates a moral hazard problem since it is not possible to verify whether agents actually pay the cost of acquiring information and whether they truthfully report their signals.

In our model, a cross-listing is a mechanism to boost stock price informativeness. This mechanism has a large impact on the value of the firm if it results in a large improvement in price informativeness. The second part of Proposition 3 gives a lower bound on the (percentage) increase in price informativeness following a cross-listing. This bound increases, other things equal, when the signal-to-noise ratio, ρ_ε, decreases. This observation suggests that the impact of a cross-listing on firm value is large when speculators have information of poor quality.

As an illustration, we report in Table 1 the percentage difference in the expected value of the firm when it is cross-listed and when it is not for various levels of the signal-to-noise ratio, ρ_ε. We focus on cases in which the signal-to-noise ratio is small and ranges from 0.01 to 0.4 for two reasons. First, as explained previously, the impact of a cross-listing on firm value is larger when informed traders have signals of poor quality in our model. Second, the rare empirical studies that structurally estimate the precision of informed traders' signals find that this precision is low. For instance, Bernhardt and Hughson (2002) obtain estimates for the

[16] The last equality does not obtain if the number of speculators is fixed exogenously. Yet, in this case as well, the illiquidity premium is larger when the firm cross-lists. This can be checked by comparing Eqs. (14) and (16) for $M^c = M^{nc}$.

Table 1
Cross-listing and signals quality

Signal-to-noise ratio: $\rho_\varepsilon = \frac{\sigma_\delta^2}{\sigma_\delta^2+\sigma_\varepsilon^2}$	0.01	0.1	0.15	0.2	0.25	0.3	0.35	0.4
Nber of informed traders with a single listing (M^{nc})	59	60	56	52	49	47	45	43
Nber of informed traders with a dual-listing (M^c)	93	80	73	67	63	60	58	55
Price informativeness with a single listing ($I(P_2^{nc})/\sigma_\theta^2$), %	22	76	81	85	87	89	90	91
Price informativeness with a dual listing ($I(P_2^c)/\sigma_\theta^2$), %	38	85	89	91	92	93	94	95
Cross-listing premium (in % of V^{nc})	10.3	4	3	2.4	2	1.7	1.5	1.3

Table 1 reports the cross-listing premium (in percentage of the value of the firm when it is not cross-listed) for various values of the signal-to-noise ratio, ρ_ε. It also gives the number of speculators purchasing information and the corresponding level of price informativeness (normalized by the variance of θ) when the firm is cross-listed and when it is not. The manager has no private information. Other parameters are chosen as follows: cost of information acquisition, $C = 0.5$; variance of costly information, $\sigma_\delta^2 = \sigma_\theta^2 = 100$; variance of liquidity trading, $\sigma_Z^{2c} = \sigma_Z^{2nc} = 100$; average value of the assets in place, $\overline{V} = 500$; size of the growth opportunity, $S = 10$; fraction of nondiscretionary liquidity demand in the domestic market, $\alpha = 0.5$; fraction of total liquidity demand due to nondiscretionary liquidity traders, $\phi = 1$; correlation between the payoff of the assets in place and the payoff of the growth opportunity, $\gamma = 1$.

signal-to-noise ratio ranging from 0.06 to 0.28 for five stocks listed on the NYSE. Similarly, Foster and Viswanathan (1995) estimate this ratio at 0.20 for IBM stock and conclude (p. 390) that "It appears that many informed traders pay little to obtain relatively imprecise information." For the interpretation, notice that $Var(\widetilde{\delta}|\widetilde{s}_i) = \sigma_\delta^2(1-\rho_\varepsilon)$. Thus, a signal-to-noise ratio equal to, say 0.06, means that an informed trader's signal reduces his uncertainty on the payoff of the assets in place by only 6%.

In Table 1, we also report the number of informed traders when the firm is cross-listed and when it is not and the corresponding level of price informativeness normalized by σ_θ^2. Thus, the level of price informativeness is the percentage reduction in the uncertainty about θ due to stock market information. For a low precision of informed traders' signals and a low cost of information acquisition, the stock price is much more informative than informed traders' private signals because it aggregates heterogeneous signals of a large number of informed traders. For instance, when $\rho_\varepsilon = 0.1$, observing the stock price reduces by 85% (76%) the uncertainty on θ when the firm is cross-listed (not cross-listed).

For all cases considered in Table 1, the parameters are such that it is optimal for the firm to cross-list (the cross-listing premium is positive). The impact of a cross-listing on the firm value ranges from 1% to 10%. As expected, for small values of ρ_ε, a cross-listing has a significant impact on price informativeness.[17] For instance, when $\rho_\varepsilon = 0.01$, a cross-listing improves price informativeness by 72% and the value of the firm by 10%. For larger values of ρ_ε (e.g. $\rho_\varepsilon = 0.4$), the impact of a cross-listing on firm value is small because stock price informativeness is large even if the firm does not cross-list, which limits the scope for improvement in stock price informativeness.

3.3. An extension

In the baseline model, we assume that speculators can trade in all markets where the firm is listed. In this case, a cross-listing is just one instrument that the firm can use to encourage information acquisition by foreign speculators. Instead, it could, for instance, issue different types of securities to leverage informed traders' ability to exploit their information (see Bond, Goldstein, and Prescott, 2006). In reality, however, regulatory hurdles or participation costs also hinder informed investors' access to foreign markets. For instance, Werner and Kleidon (1996) note that (p. 658): "Overall the evidence suggests that market switching costs are high enough to prevent a substantial share of U.S. informed traders from placing their orders in London."

In this case, a cross-listing is the *only* way to induce information acquisition by foreign speculators. It is especially attractive for the firm when foreign speculators have access to information that is not readily

[17] Of course, for very small values of ρ_ε, the impact of a cross-listing on firm value is small because stock price informativeness is small even if the firm cross-lists. For instance, for the parameter values considered in Table 1, if $\rho_\varepsilon = 0.005$, the cross-listing premium is equal to 6%, which is smaller than its value when $\rho_\varepsilon = 0.01$.

available to domestic speculators, such as information on the demand for products of the firm sold in the foreign country.

The baseline model can be modified to study this scenario. Suppose that all investors (speculators and liquidity traders) can trade only in their home market and that

$$\widetilde{\delta} = \widetilde{\delta}_L + \widetilde{\delta}_F, \tag{25}$$

where $\widetilde{\delta}_L$ and $\widetilde{\delta}_F$ are independently and normally distributed, with mean zero and variances $\sigma_\delta^2/2$. Speculators in country L observe a signal $\widetilde{s}_{iL} = \widetilde{\delta}_L + \widetilde{\varepsilon}_i$ at cost C. Their cost of obtaining information on $\widetilde{\delta}_F$ (the foreign component of the firm's cash flows) is high so that no trader in country L acquires this information. Symmetric assumptions are made for speculators in country F. Other assumptions of the model are unchanged.

In this case, we show in Appendix B that a cross-listing enhances price informativeness, as in the baseline model. The result is not entirely straightforward because a cross-listing may result in less liquidity trading in the domestic market.[18] For this reason, it can reduce domestic speculators' expected profits and thereby trigger a decline in the number of domestic speculators. This effect has a negative impact on price informativeness. However, in equilibrium, it is always outweighed by entry of foreign speculators. The rest of the results are qualitatively unchanged because they derive from the fact that a cross-listing strengthens price informativeness.

4. Testable implications

The model has four types of testable implications: (a) implications for the determinants of the cross-listing decision, (b) implications for the relationship between stock prices and investment decisions, (c) implications for changes in the value of growth opportunities around a cross-listing, and (d) implications for the determinants of the cross-listing premium.

The determinants of the decision to cross-list: As a cross-listing enhances the value of the growth opportunity, it is optimal to cross-list when the size of the growth opportunity is large enough, as claimed in the next proposition.

Proposition 7 (*the decision to cross-list*). *Other things equal, a firm chooses to cross-list* ($\Delta V > 0$) *if and only if the size of its growth opportunity is larger than a cutoff value* (*derived in the appendix*) *that* (a) *increases with the quality of managerial information* (*i.e.*, $1/\sigma_m^2$) *and* (b) *decreases with the correlation between the payoffs of the asset in place and the growth opportunity*, γ.

For a fixed size of the growth opportunity, the informational benefit of a cross-listing is greater when managerial information is poor and when the correlation between the payoffs of the asset in place and the growth opportunity is higher (since the stock price is informative on the value of the asset in place). The second part of the proposition follows.

This proposition implies that, for a given firm, the likelihood of a cross-listing is (i) positively related to the size of growth opportunities, (ii) inversely related to the quality of managerial information, and (iii) positively related to the correlation between the payoffs of the asset in place and the growth opportunity.

Recent empirical findings support the prediction that firms with larger growth opportunities are more likely to cross-list (see Pagano, Roëll, and Zechner, 2002; Doidge, Karolyi, Lins, Miller, and Stulz, 2006; Claessens, Klingebiel, and Schmukler, 2003). For instance, Doidge, Karolyi, Lins, Miller, and Stulz (2006) write (p. 21): "We consistently find that firms with better growth opportunities ...are more likely to be cross-listed on a U.S. exchange." Similarly, Pagano, Roëll, and Zechner (2002) find that the likelihood of a cross-listing is significantly and positively related to indicators of growth opportunities, such as the price-to-book ratio and asset growth rate.[19]

[18] This happens if the increase in aggregate liquidity demand following a cross-listing, i.e., $\sigma_Z^{2c} - \sigma_Z^{2nc}$, is small.

[19] Gozzi, Levine, and Schmukler (2005) observe that cross-listed firms experience an increase in their Tobin-q, at a faster rate than non cross-listed firms, in the years preceding their cross-listing. This observation also supports the prediction that firms with large growth opportunities are more likely to cross-list.

Cross-listings and the sensitivity of investment decisions to stock price: The relationship between investment and the stock price is given by Eq. (19) that we rewrite here for the discussion

$$K^*(s_m, P_3^k) = K_0 + \frac{\tau_m}{\tau_m + \tau_k} s_m + \frac{\tau_k \sqrt{\gamma}}{\tau_m + \tau_k}(P_3^k - \overline{V}),$$

where $\tau_m = 1/\sigma_m^2$ is the precision of managerial information and $\tau_k \equiv (Var(\theta|P_3^k))^{-1}$. As $(Var(\theta|P_3^k))^{-1} = (\sigma_\theta^2 - I(P_3^k))^{-1}$, τ_k increases with stock price informativeness. The sensitivity of investment to stock price (after controlling for managerial information) is

$$\frac{\partial K^*}{\partial P_3^k} = \frac{\tau_k \sqrt{\gamma}}{\tau_m + \tau_k}, \quad k \in \{c, nc\}. \tag{26}$$

The sensitivity of investment to stock price is strictly positive if managerial information is imperfect, $\tau_m < \infty$ and the stock price is informative, $\tau_k > 0$. Moreover, it increases with the informativeness of the stock price, τ_k, and decreases with the quality of managerial information. Chen, Goldstein, and Jiang (2007) provide evidence supporting these two implications, which obtain whether the firm is cross-listed or not. Last, $\tau_c > \tau_{nc}$, as a cross-listing enhances the informativeness of stock prices. Thus, the model has the following implication.

Proposition 8. *The sensitivity of investment to stock price for a given firm is larger when it is cross-listed than when it is not. Moreover, cross-sectionally, the increase in the sensitivity of investment to stock price following a cross-listing is larger for firms in which* (i) *nondiscretionary traders account for a larger fraction of total liquidity demand* (ϕ *high*) *and* (ii) *nondiscretionary liquidity demand is geographically less concentrated* ($i(\alpha)$ *low*).

The increase in the sensitivity of investment to stock price following a cross-listing is fully explained by the improvement in price informativeness in our model. That is, managers rely more on the stock market as a source of information for their investment decisions after a cross-listing because their stock price is then more informative. Thus, the effect of a cross-listing on the sensitivity of investment to stock price should disappear after controlling for the impact of price informativeness. Moreover, the effect of a cross-listing on this sensitivity increases when the impact of a cross-listing on price informativeness is stronger (i.e., $(\tau_c - \tau_{nc})$ enlarges). Thus, this effect increases with factors that positively affect the impact of a cross-listing on price informativeness. Such factors in our model are a decrease in $i(\alpha)$ or an increase in ϕ (Proposition 3). This observation explains the second part of the proposition.

Cross-listing and the value of growth opportunities: Proposition 5 implies that the value of growth opportunities should increase after a cross-listing.[20] In line with this implication, Hail and Leuz (2005) find that financial analysts mark up their forecasts for a firm's long-term growth after a cross-listing. The next proposition analyzes in more detail the determinants of the improvement in the value of growth opportunities after a cross-listing.

Proposition 9. *The difference between the expected value of the growth opportunity when the firm is cross-listed and when it is not*, ΔEG,

- *increases when nondiscretionary traders account for a larger fraction of total liquidity demand* (ϕ *increases*),
- *decreases when nondiscretionary liquidity demand becomes geographically more concentrated* ($i(\alpha)$ *increases*),
- *decreases with the quality of managerial information* ($1/\sigma_m^2$ *increases*), *and*
- *increases in the correlation between the payoffs of the assets in place and the growth opportunity* (γ).

Changes in the characteristics of the firm (e.g., a more even allocation of shares between domestic and foreign nondiscretionary liquidity traders) that enhance price informativeness result in more efficient investment decisions and, therefore, a larger expected value for the growth opportunity. Moreover, when the precision of managerial information declines (i.e., σ_m^2 increases), stock price information is more valuable for the manager. Thus, the impact of a cross-listing on the expected value of growth opportunities is larger when managerial information is poor.

[20] The corporate finance literature has developed several proxies for measuring growth opportunities; see Cao, Simin, and Zhao (2006) for a review.

The cross-listing premium: Doidge, Karolyi, and Stulz (2004) (henceforth DKS, 2004) find that firms cross-listed in the U.S. have larger valuations than firms that do not cross-list (see also Hail and Leuz, 2005; King and Segal, 2006).

In our model, only firms with sufficiently large growth opportunities cross-list. Thus, other things equal, the value of a cross-listed firm is larger than the value of a non-cross-listed firm. DKS (2004) show, however, that the cross-listing premium persists even after controlling for measures of growth opportunities and self-selection. Moreover, they find that the cross-listing premium is largely due to the fact that growth opportunities have a larger positive impact on firm value for cross-listed firms (see Table 5 in DKS, 2004).

DKS (2004) argue that this finding is due to more stringent governance rules in the U.S. (the bonding hypothesis). Our model suggests another explanation. To show this point, using Lemma 4, we write the difference in the value of a given firm when it is cross-listed and when it is not (Eq. (24)) as a function of the size of its growth opportunities. We obtain

$$\Delta V = \psi S - \Delta T, \tag{27}$$

with

$$\psi \overset{def}{=} \left(\frac{\sigma_\theta^4 + (\sigma_m^2 - \sigma_\theta^2) I(P_3^c)}{2(\sigma_m^2 + \sigma_\theta^2 - I(P_3^c))} - \frac{\sigma_\theta^4 + (\sigma_m^2 - \sigma_\theta^2) I(P_3^{nc})}{2(\sigma_m^2 + \sigma_\theta^2 - I(P_3^{nc}))} \right). \tag{28}$$

Parameter ψ measures the difference in the sensitivity of the value of the firm to the size of its growth opportunities if it cross-lists and if it does not. It is always positive (as shown in the proposition below). This property is key as it drives the existence of the cross-listing premium (that is, $\Delta V > 0$ for a cross-listed firm because $\psi > 0$). Thus, as found empirically in DKS (2004), the cross-listing premium is due to the fact that a manager better exploits its growth opportunity if her firm is cross-listed. But the reason here is that the firm benefits from a more precise stock market signal after a cross-listing, not an improvement in its governance. The next proposition derives additional predictions regarding the determinants of ψ that could be used to distinguish empirically our explanation for the cross-listing premium from that provided by the bonding hypothesis.

Proposition 10. *The cross-listing premium increases with the size of the growth opportunity*, S, *that is* $\psi > 0$. *Moreover, the sensitivity of the cross-listing premium* (ψ) *to the size of the growth opportunity*:

(1) *increases when the precision of managerial information decreases* (σ_m^2 *increases*),
(2) *increases when nondiscretionary traders account for a larger fraction of total liquidity demand* (ϕ *increases*), *and*
(3) *decreases when nondiscretionary liquidity demand becomes geographically more concentrated* ($i(\alpha)$ *increases*).

The intuition for these predictions is as follows. A cross-listing allows firms to exploit more efficiently their growth opportunities. This efficiency gain increases with the improvement in price informativeness after a cross-listing. Thus, factors strengthening price informativeness (e.g., an increase in ϕ or a decrease in $i(\alpha)$) or making stock market information relatively more valuable (an increase in σ_m^2) enhance the sensitivity of the cross-listing premium to the size of growth opportunities.

Cross-listing premium and trading location: In the model, parameter α affects both the cross-listing premium and the distribution of trading activity among the two markets. Thus, the cross-listing premium is correlated with the extent of trading concentration in the foreign or domestic market. To our knowledge, no empirical study relates the cross-listing premium to trading concentration, despite evidence of cross-sectional variations in the distribution of trading activity between foreign, and domestic markets (Halling, Pagano, Randl, and Zechner, 2005; Baruch, Karolyi, and Lemmon, 2006).

Trading concentration in the model can be measured by $\Gamma(\alpha) \overset{def}{=} 2i(\alpha) = 2|\alpha - 50\%|$. Indeed, this index varies from zero, when exchanges L and F have equal market shares, to one when one exchange captures all trading. It is difficult to study analytically the relationship between trading concentration and the cross-listing premium. Thus, we first provide a numerical example and then explain why this example is representative of the relationship between trading concentration and the cross-listing premium in general.

Table 2
Cross-listing premium and trading concentration

Trading concentration: $\Gamma(\alpha) = 2i(\alpha)$ (%)	Cross-listing premium (in % of V^{nc})		
	$S = 5$ (%)	$S = 10$ (%)	$S = 15$ (%)
0	1.91	4	5.46
20	1.93	4.05	5.39
40	1.93	4.05	5.39
60	1.95	3.97	5.25
80	1.99	3.79	4.93
98	1.98	3.37	4.26

Table 2 reports the cross-listing premium (in percentage of the value of the firm when it is not cross-listed) for various values of trading concentration, $\Gamma(\alpha)$, and the size of the growth opportunity, S. The manager has no private information. Other parameters are chosen as follows: cost of information acquisition, $C = 0.5$; variance of costly information, $\sigma_\delta^2 = \sigma_\theta^2 = 100$; variance of liquidity trading, $\sigma_Z^{2c} = \sigma_Z^{2nc} = 100$; signal-to-noise ratio, $\rho_\varepsilon = 0.1$; average value of the assets in place, $\overline{V} = 500$; fraction of nondiscretionary liquidity demand in the domestic market, $\alpha = 0.5$; fraction of total liquidity demand due to nondiscretionary liquidity traders, $\phi = 1$; correlation between the payoff of the assets in place and the payoff of the growth opportunity, $\gamma = 1$.

Table 2 reports the value of the cross-listing premium for various values of trading concentration and different sizes of the growth opportunity. Other parameters are as in the first numerical example (Table 1), with $\rho_\varepsilon = 0.1$. Table 2 shows that the relationship between the cross-listing premium and trading concentration depends on the size of the growth opportunity. Namely, if the size of the growth opportunity is large enough (e.g., $S = 15$) then the cross-listing premium is maximum when trading concentration is minimum. For smaller sizes of the growth opportunity, the relationship between the cross-listing premium and trading concentration is non-monotonic. The cross-listing premium increases with trading concentration for low levels of concentration and then decreases with trading concentration for higher levels (consider $S = 10$ for instance).

This is a general pattern that is easily explained. A decrease in trading concentration (e.g., a smaller $i(\alpha)$) has two opposite effects on the cross-listing premium. On the one hand, it improves the expected value of the growth opportunity because it improves price informativeness (Propositions 3 and 9). On the other hand, it increases the illiquidity premium because it fragments liquidity trading (Proposition 6). Which effect dominates is determined by the size of growth opportunities. If this size is large then the benefit of getting a more precise signal from the stock market swamps the increase in the illiquidity premium. Thus, when the growth opportunity is large enough, the cross-listing premium decreases with trading concentration and is maximum for $\Gamma(\alpha) = 0$, that is, $\alpha = 50\%$. Otherwise, the cross-listing premium reaches a maximum for $\Gamma(\alpha) > 0$.

Thus, the model implies a cross-sectional correlation between the cross-listing premium and the extent of trading concentration. The sign of this correlation depends on the size of growth opportunities, however. It should be positive for firms with relatively small growth opportunities and negative for firms with relatively large growth opportunities.

Some studies show that trading concentrates in the domestic market for some cross-listed stocks (e.g., Halling, Pagano, Randl, and Zechner, 2005; Karolyi, 2003). Interestingly, our numerical findings show that the cross-listing premium does not vanish even when trading is heavily concentrated in the foreign or the domestic market (e.g., $\Gamma = 98\%$). The reason for this result is the following. As trading concentrates in one market, the impact of a cross-listing on the number of speculators and the illiquidity premium becomes smaller. In fact, it vanishes if $\sigma_Z^{2c} = \sigma_Z^{2nc}$ (as assumed in Table 2). But a cross-listing still has a significant impact on price informativeness because it enlarges the number of price signals available to market participants. Thus, as explained after Proposition 3, a cross-listing triggers a discrete jump in the level of price informativeness and the value of the firm, even if trading concentrates in the domestic market.[21]

[21]Accordingly, the lower bound on the improvement in price informativeness following a cross-listing does not depend on α (see Proposition 3).

Table 2 shows that this effect is in itself more important than the allocation of trading between the domestic market and the foreign market. For instance, when $S=10$, a cross-listing results in an improvement in the firm value of at least 3%, even if trading concentrates in the domestic market, while a change in trading concentration can result, at most, in an improvement of about 1% in the value of the firm (see Table 2).

5. Conclusion

This paper develops a new theory of cross-listings. In this theory, managers extract information from stock prices to make investment decisions. As a cross-listing enhances price informativeness, it helps managers to incorporate market expertise and to make more informed investment decisions, thereby leveraging their ability to take advantage of their growth opportunities. Accordingly, firms with sufficiently large growth opportunities cross-list and the value of a cross-listed firm is larger than an otherwise similar, non-cross-listed firm. This cross-listing premium increases in the size of growth opportunities and is inversely related to the quality of managerial information.

The theory has a rich set of new testable implications. In particular, it implies that the sensitivity of investment decisions to stock price should increase after a cross-listing. Moreover, it relates (a) the change in the expected value of future growth opportunities and (b) the cross-listing premium to the quality of managerial information, the fraction of total liquidity demand due to captive liquidity traders, and the distribution of captive liquidity demands between the foreign market and the domestic market. We suggest using the shareholding structure of the firm after a cross-listing to build proxies for these components of total liquidity demand.

A cross-listing in U.S. markets obliges firms to additional disclosures, as they must reconcile their accounting statements with U.S. GAAP (Generally Accepted Accounting Principles). These disclosures increase the level of public information and lower the profitability of acquiring private information. Thus, more stringent disclosure rules when a firm cross-lists should reduce both the benefit and the cost of a cross-listing in our model. In this case, these rules can help firms to keep the illiquidity premium low while reaping the benefit of greater price informativeness through the increase in the number of price signals available about the firm. A detailed examination of the impact of increased disclosures on the trade-off analyzed in our paper is an interesting venue for future research.[22] It would help to better delineate the set of cross-listed firms for which our theory applies and further our understanding of firms' disclosures on price volatility.[23]

Appendix A. Proofs

A.1. Proof of Lemma 2

The equilibrium number of informed investors, M^{c*}, when the firm is cross-listed solves (see Eq. (17))

$$\frac{\sqrt{\rho_\varepsilon}}{(2+(M^{c*}-1)\rho_\varepsilon)\sqrt{M^{c*}}}\left(\sqrt{(2\phi\sqrt{\alpha(1-\alpha)}+1)\sigma_\delta^2\sigma_Z^{2c}}\right)=C \tag{29}$$

which is equivalent to

$$\frac{\sqrt{\rho_\varepsilon}}{(2+(M^{c*}-1)\rho_\varepsilon)\sqrt{M^{c*}}}\left(\sqrt{\left(2\phi\sqrt{\frac{1}{4}-(i(\alpha))^2}+1\right)\sigma_\delta^2\sigma_Z^{2c}}\right)=C. \tag{30}$$

The left hand side of this equation decreases with $i(\alpha)$, increases with ϕ, and decreases with M^{c*}. Thus, the equilibrium number of informed traders decreases with $i(\alpha)$ and increases with ϕ when the firm is cross-listed.

[22] Fernandes and Ferreira (2005) find that firms of emerging countries experience a reduction in the informativeness of their stock price after cross-listing in the U.S. One possibility, discussed by Fernandes and Ferreira (2005), is that for emerging markets, the disclosure effect is very strong because accounting standards are more lenient or not well enforced in emerging countries.

[23] Bailey, Karolyi, and Salva (2006) find that price volatility around earnings announcements increases after a cross-listing. They note that this finding is puzzling as increased disclosure should lead to less informed trading.

When the firm is not cross-listed, the equilibrium number of informed traders solves

$$\frac{\sqrt{\rho_\varepsilon}}{(2+(M^{nc*}-1)\rho_\varepsilon)\sqrt{M^{nc*}}}\left(\sqrt{\sigma_\delta^2\sigma_Z^{2nc}}\right)=C. \tag{31}$$

We deduce from Eqs. (29) and (31) that $M^{nc*}<M^{c*}$ if and only if

$$(2\phi\sqrt{\alpha(1-\alpha)}+1)\sigma_Z^{2c}>\sigma_Z^{2nc}, \tag{32}$$

which is satisfied since $\sigma_Z^{2c}\geqslant\sigma_Z^{2nc}$ and $0<\alpha<1$.

A.2. Proof of Proposition 3

Part 1.

Case 1: *the firm is cross-listed.* Using the fact that $\tilde{\delta}$, P_L^c, and P_F^c are normally distributed and standard properties of multivariate normal distributions, we obtain after tedious computations

$$P_3^c=\overline{V}+E(\tilde{\delta}|P_L^c,P_F^c)=\overline{V}+\Upsilon(\lambda_L^*O_L+\lambda_F^*O_F), \tag{33}$$

where $O_j=\sum_{i=1}^{i=M^c}Q_j(s_i)+Z_{jd}+Z_j$ and Υ is a constant given by

$$\Upsilon=\frac{2+(M^{c*}-1)\rho_\varepsilon}{(3+2(M^{c*}-1)\rho_\varepsilon)+\dfrac{\sigma_d^2}{\sigma_d^2+(\sigma_L+\sigma_F)^2}}. \tag{34}$$

Clearly, P_3^c has a normal distribution as O_L and O_F are normally distributed. It follows from the definition of $I(P_3^c)$ and normal theory that

$$I(P_3^c)=Var(E(\tilde{\theta}|P_3^c)). \tag{35}$$

Using the law of iterated expectations

$$E(\tilde{\theta}|P_3^c)=E(E(\tilde{\theta}|\tilde{\delta})|P_3^c). \tag{36}$$

Using Eq. (3), we deduce that $E(\tilde{\theta}|\tilde{\delta}=\delta)=(\gamma)^{\frac{1}{2}}\delta$. Thus

$$I(P_3^c)=\gamma Var(E(\tilde{\delta}|P_3^c)). \tag{37}$$

Hence, using Eq. (33), we obtain that

$$I(P_3^c)\overset{def}{=}\gamma\Upsilon^2Var(\lambda_L^*O_L+\lambda_F^*O_F). \tag{38}$$

We deduce that

$$I(P_3^c)=\gamma\Upsilon^2\left[(M^{c*}\lambda_L^*\beta_L^*+M^{c*}\lambda_F^*\beta_F^*)^2\left(\sigma_\delta^2+\frac{\sigma_\varepsilon^2}{M^{c*}}\right)\right.$$
$$\left.+\lambda_L^2((w_L^*)^2\sigma_d^2+\sigma_L^2)+\lambda_F^2((w_F^*)^2\sigma_d^2+\sigma_F^2)+2\lambda_L^*\lambda_F^*w_F^*w_L^*\sigma_d^2\right]. \tag{39}$$

Substituting λ_L^*, λ_F^*, β_L^*, β_F^*, w_L^* and w_F^* by their expressions given in Lemma 1 and simplifying, we obtain (after tedious calculations)

$$I(P_3^c)=\frac{2M^{c*}\gamma\rho_\varepsilon\sigma_\delta^2}{3+2(M^{c*}-1)\rho_\varepsilon+\dfrac{\sigma_d^2}{\sigma_d^2+(\sigma_L+\sigma_F)^2}}. \tag{40}$$

Using the definitions of σ_d^2, σ_L^2 and σ_F^2 (see Eqs. (8), (9) and (10)), we obtain

$$I(P_3^c)=\frac{2M^{c*}\gamma\rho_\varepsilon\sigma_\delta^2}{3+2(M^{c*}-1)\rho_\varepsilon+\dfrac{(1-\phi)}{1+2\phi\sqrt{\alpha(1-\alpha)}}}. \tag{41}$$

Case 2: *The firm is not cross-listed.* In this case,

$$P_3^{nc} = \overline{V} + E(\widetilde{\delta}|P_L^{nc}) = \overline{V} + \lambda_L^* O_L. \tag{42}$$

Using this remark, we can then proceed as in Case 1 and we obtain

$$I(P_3^{nc}) = \gamma Var(E(\widetilde{\delta}|P_3^{nc})) = \frac{M^{nc*}\gamma\rho_\varepsilon\sigma_\delta^2}{(2+(M^{nc*}-1)\rho_\varepsilon)}. \tag{43}$$

Thus, we have

$$\frac{I(P_3^c)}{I(P_3^{nc})} = \left(\frac{2(2+(M^{nc*}-1)\rho_\varepsilon)}{3+2(M^{c*}-1)\rho_\varepsilon + \dfrac{(1-\phi)}{1+2\phi\sqrt{\alpha(1-\alpha)}}}\right)\frac{M^{c*}}{M^{nc*}}. \tag{44}$$

As $M^{c*} \geqslant M^{nc*}$, we deduce after some algebra that

$$\frac{I(P_3^c)}{I(P_3^{nc})} > 1 + \frac{\phi}{2(M^{nc*}-1)\rho_\varepsilon + 4 - \phi}. \tag{45}$$

Thus, $I(P_3^c) > I(P_3^{nc})$ and $(I(P_3^c) - I(P_3^{nc}))/I(P_3^{nc}) > \phi/(2(M^{nc*}-1)\rho_\varepsilon + 4 - \phi)$. Hence the first part of the proposition is proved.

Part 2.

Using Eq. (41), we can write $I(P_3^c)$ as a function of ϕ and $i(\alpha)$. We obtain

$$I(P_3^c) = \frac{2M^{c*}\gamma\rho_\varepsilon\sigma_\delta^2}{3+2(M^{c*}-1)\rho_\varepsilon + \dfrac{(1-\phi)}{1+2\phi\sqrt{\frac{1}{4}-(i(\alpha))^2}}}. \tag{46}$$

Let this function be $I^c(M^{c*}, i(\alpha), \phi)$. Differentiation of I^c with respect to $i(\alpha)$ yields

$$\frac{dI^c}{d\alpha} = \frac{\partial I^c}{\partial M^{c*}}\frac{\partial M^{c*}}{\partial i(\alpha)} + \frac{\partial I^c}{\partial i(\alpha)}. \tag{47}$$

It is immediate that $\partial I^c/\partial M^{c*} > 0$ and that $\partial I^c/\partial i(\alpha) < 0$. Moreover, $\partial M^{c*}/\partial i(\alpha) < 0$ (Lemma 2). We deduce that $\mathrm{d}I^c/\mathrm{d}i(\alpha) < 0$. We also have

$$\frac{\mathrm{d}I^c}{\mathrm{d}\phi} = \frac{\partial I^c}{\partial M^{c*}}\frac{\partial M^{c*}}{\partial \phi} + \frac{\partial I^c}{\partial \phi}. \tag{48}$$

As $\partial I^c/\partial\phi > 0$ and $\partial M^{c*}/\partial\phi > 0$ (see Proposition 2), we deduce that $\mathrm{d}I^c/\mathrm{d}\phi > 0$. Thus, the second part of the proposition is proved.

Part 3. Eq. (1) and Eq. (12) imply

$$Var(P_3^k - \overline{V}) = Var(E(\widetilde{\delta}|P_3^k)). \tag{49}$$

Thus, using Eq. (37), we deduce that $Var(P_3^k - \overline{V}) = \gamma^{-1}I(P_3^k)$. It follows from Part 1 that

$$Var(P_3^{nc} - \overline{V}) < Var(P_3^c - \overline{V}). \tag{50}$$

A.3. Proof of Lemma 4

From normal theory, we obtain that

$$Var(E(\widetilde{\theta}|\widetilde{s}_m, P_3^k)) = \sigma_\theta^2 - Var(\widetilde{\theta}|\widetilde{s}_m, P_3^k) = \sigma_\theta^2 - \frac{1}{\tau_m + \tau_k}, \quad \text{for } k \in \{c, nc\}, \tag{51}$$

where $\tau_m = (\sigma_m^2)^{-1}$ and $\tau_k \overset{def}{=} (Var(\widetilde{\theta}|P_3^k))^{-1} = (\sigma_\theta^2 - I(P_3^k))^{-1}$. Substituting τ_m and τ_k by their expression in Eq. (51) and simplifying, we obtain

$$Var(E(\widetilde{\theta}|\widetilde{s}_m, P_3^k)) = \left(\frac{\sigma_\theta^4 + (\sigma_m^2 - \sigma_\theta^2)I(P_3^k)}{\sigma_m^2 + \sigma_\theta^2 - I(P_3^k)}\right), \quad \text{for } k \in \{c, nc\}. \tag{52}$$

The expression for the expected value of the growth opportunity directly follows from this equation and Eq. (21). It is immediate that $\partial EG^k/\partial I(P_3^k) > 0$ if $\sigma_m^2 > 0$.

A.4. Proof of Proposition 5

Immediate from Proposition 3 and Lemma 4.

A.5. Proof of Proposition 6

The first part of the proposition follows from Eq. (23). The second part follows from the fact that in equilibrium $T^c = CM^{c*}$ and Lemma 2.

A.6. Proof of Proposition 7

Let us define

$$\psi = \frac{Var(E(\tilde{\theta}|\widetilde{s}_m, P_3^c)) - Var(E(\tilde{\theta}|\widetilde{s}_m, P_3^{nc}))}{2}. \tag{53}$$

Observe that

$$\Delta V = \psi S - C(M^{c*} - M^{nc*}). \tag{54}$$

Moreover, from Eq. (52) in the proof of Lemma 4, we deduce that

$$\psi = \left(\frac{\sigma_\delta^4 + (\sigma_m^2 - \sigma_\delta^2)I(P_3^c)}{\sigma_m^2 + \sigma_\delta^2 - I(P_3^c)}\right) - \left(\frac{\sigma_\delta^4 + (\sigma_m^2 - \sigma_\delta^2)I(P_3^{nc})}{\sigma_m^2 + \sigma_\delta^2 - I(P_3^{nc})}\right). \tag{55}$$

Observe that ψ and $C(M^{c*} - M^{nc*})$ do not depend on S. Moreover, observe that $\psi > 0$ because $I(P_3^c) > I(P_3^{nc})$ (Proposition 3). Therefore (i) ΔV increases with S, the size of the growth opportunity and (ii) there exists a threshold S^* such that $\Delta V \geqslant 0$ if and only if $S \geqslant S^*$. Eq. (54) yields

$$S^* = \frac{2C(M^{c*} - M^{nc*})}{\psi}. \tag{56}$$

We note that σ_m^2 and γ do not affect the number of informed traders in equilibrium and that ψ increases with σ_m^2 and γ (use Eq. (41), Eq. (55) and Eq. (43)). We deduce from Eq. (56) that S^* decreases with σ_m^2 and γ.

A.7. Proof of Proposition 8

It follows directly from Eq. (26) and Proposition 3.

A.8. Proof of Proposition 9

Recall that $I(P_3^c)$ decreases with $i(\alpha)$ and increases with ϕ (Proposition 3). As EG^c increases with $I(P_3^c)$ (Lemma 4), we deduce that EG^c decreases with $i(\alpha)$ and increases with ϕ. These parameters do not affect EG^{nc}. Hence the effects of these parameters on ΔEG and on EG^c are identical. The first two points of the proposition follow. Finally, direct calculations show that $\partial\Delta EG/\partial\sigma_m^2 > 0$ (third part) and $\partial\Delta EG/\partial\gamma > 0$ (fourth part).

A.9. Proof of Proposition 10

We have shown in the proof of Proposition 7 that $\psi > 0$ and that $\partial\psi/\partial\sigma_m^2 > 0$. Moreover, observe that ψ increases with $I(P_3^c)$, which increases with ϕ and decreases with i(α). As $I(P_3^{nc})$ does not depend on these parameters, the second part of Proposition 10 follows.

Appendix B. Extension

For brevity, we just outline the key features of the equilibrium for the extension of the model described in Section 3.3. We denote by M_j^k the number of speculators in market $j \in \{L, F\}$ in regime $k \in \{c, nc\}$. Other notations are identical to those used in the rest of the paper.

Stock Market Equilibrium: When the firm is cross-listed, in equilibrium, dealers' price schedule in market $j \in \{L, F\}$ is such that

$$P_j(O_j) = \overline{V} + \lambda_j^c O_j, \tag{57}$$

with $O_j = \sum_{i=1}^{i=M_j^c} Q_j(s_{ij}) + Z_j$ and

$$\lambda_j^c = \frac{\sqrt{M_j^c \rho_\varepsilon}}{(2 + (M_j^c - 1)\rho_\varepsilon)} \sqrt{\frac{\sigma_{\delta_j}^2}{\sigma_j^2}} \quad \text{with } j \in \{L, F\}. \tag{58}$$

Moreover, in equilibrium, speculators' optimal order placement strategies in market j are

$$Q_j(s_{ij}) = \beta_j^c s_{ij}, \quad \text{for } i \in \{1, \ldots, M_j^c\}, \tag{59}$$

with $\beta_j^c = \rho_\varepsilon/(2 + (M_j^c - 1)\rho_\varepsilon)\lambda_j^c$.

Observe that the equilibrium is identical to that obtained in the baseline model for $\phi = 1$, except that (i) M^c is replaced by M_j^c and (ii) σ_δ^2 is replaced by $\sigma_{\delta_j}^2$ in all expressions. This remark also applies when the firm is not cross-listed. In this case, the coefficients λ_L^{nc} and β_L^{nc} characterizing the equilibrium of the stock market are such that

$$\lambda_L^{nc} = \frac{\sqrt{M^{nc} \rho_\varepsilon}}{(2 + (M^{nc} - 1)\rho_\varepsilon)} \sqrt{\frac{\sigma_{\delta_L}^2}{\sigma_Z^{2nc}}}, \tag{60}$$

and

$$\beta_L^{nc} = \frac{\rho_\varepsilon}{(2 + (M^{nc} - 1)\rho_\varepsilon)\lambda_L^{nc}}. \tag{61}$$

Using the fact that $\sigma_{\delta_j}^2 = \sigma_\delta^2/2$. We deduce that when the firm is cross-listed, the aggregate, expected profit for speculators based in country j is

$$\Pi^c(M_j^c) = \frac{\sqrt{M_j^c \rho_\varepsilon}\sqrt{0.5\sigma_\delta^2 \sigma_j^2}}{(2 + (M_j^c - 1)\rho_\varepsilon)} \quad \text{with } j \in \{L, F\}. \tag{62}$$

In equilibrium, the number of informed traders in country j solves

$$\Pi^c(M_j^{c*})/M_j^{c*} = C. \tag{63}$$

When the firm is not cross-listed, the aggregate speculators' expected profit for speculators based in country j is

$$\Pi^{nc}(M^{nc}) = \frac{\sqrt{M^{nc} \rho_\varepsilon}\sqrt{0.5\sigma_\delta^2 \sigma_Z^{2nc}}}{(2 + (M^{nc} - 1)\rho_\varepsilon)}, \tag{64}$$

and in equilibrium, the number of informed traders when the firm is not cross-listed solves

$$\Pi^{nc}(M^{nc*})/M^{nc*} = C. \tag{65}$$

Price Informativeness: When the firm is cross-listed, the price at the beginning of Stage 3 is

$$P_3^c = E(\widetilde{V}|P_L^c, P_F^c) = \overline{V} + \lambda_L^c O_L + \lambda_F^c O_F, \tag{66}$$

because $O_L$and O_F are independent. When the firm is not cross-listed

$$P_3^{nc} = E(\widetilde{V}|P_L^{nc}) = \overline{V} + \lambda_L^{nc} O_L. \tag{67}$$

Following the same steps as in the proof of Proposition 3, we deduce that measures of price informativeness when the firm is cross-listed and when it is not are given by

$$I(P_3^c) = \frac{\gamma\rho_\varepsilon\sigma_\delta^2}{2}\left(\frac{M_L^{c*}}{2+(M_L^{c*}-1)\rho_\varepsilon} + \frac{M_F^{c*}}{2+(M_F^{c*}-1)\rho_\varepsilon}\right), \tag{68}$$

$$I(P_3^{nc}) = \frac{\gamma\rho_\varepsilon\sigma_\delta^2}{2}\left(\frac{M^{nc*}}{2+(M^{nc*}-1)\rho_\varepsilon}\right). \tag{69}$$

We now prove that price informativeness is always larger when the firm is cross-listed ($I(P_3^c) > I(P_3^{nc})$). Observe that, for $j \in \{L, F\}$,

$$\frac{\Pi^c(M_j^{c*})/M_j^{c*}}{\Pi^{nc}(M^{nc*})/M^{nc*}} = \frac{(2+(M^{nc*}-1)\rho_\varepsilon)\sqrt{M^{nc*}}}{(2+(M_j^{c*}-1)\rho_\varepsilon)\sqrt{M_j^{c*}}}\sqrt{\frac{\sigma_j^2}{\sigma_Z^2}} = 1 \tag{70}$$

First, consider the case in which $\sigma_Z^{2nc} < Max\{\sigma_L^2, \sigma_F^2\}$, i.e., $\sigma_Z^{2nc} < Max\{\alpha, (1-\alpha)\}\sigma_Z^{2c}$. In this case, Eq. (70) implies that $M^{nc*} < Max\{M_L^{*c}, M_F^{*c}\}$. It is then immediate (using Eqs. (68) and (69)) that $I(P_3^c) > I(P_3^{nc})$. Now suppose that $\sigma_Z^{2nc} \geqslant Max\{\alpha, (1-\alpha)\}\sigma_Z^{2c}$. In this case, $M^{nc*} \geqslant Max\{M_L^{*c}, M_F^{*c}\}$. We deduce from Eq. (70) that

$$\sqrt{\frac{M^{nc*}\alpha}{M_L^{c*}}} < 1 \quad \text{and} \quad \sqrt{\frac{M^{nc*}(1-\alpha)}{M_F^{c*}}} < 1. \tag{71}$$

Using Eq. (71), Eq. (68), and the fact that $M_j^{c*} < M^{nc*}$, we deduce that

$$I(P_3^c) > \frac{\gamma\rho_\varepsilon\sigma_\delta^2}{2}\left(\frac{\alpha M^{nc*}}{2+(M^{nc*}-1)\rho_\varepsilon} + \frac{(1-\alpha)M^{nc*}}{2+(M^{nc*}-1)\rho_\varepsilon}\right), \tag{72}$$

which implies $I(P_3^c) > I(P_3^{nc})$.

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