A Two-Sided Market Analysis of Stock Exchanges

by Jose Miguel M. Abito

Honours Thesis in part fulfilment for the Honours B.Soc.Sci. degree presented to the
Department of Economics, National University of Singapore AY2005/2006.

Abstract

This thesis attempts to model stock exchanges under a given set of industrial environments and within a two-sided market framework. We examine the optimal trading and listing fees that an exchange sets under monopoly and duopoly competition. Limiting our model to the special case where trading services from stock exchanges are independent and nonsubstitutable goods, we have shown that dual-listing can either increase or decrease listing fees, depending on how differentiated the listing services of exchanges are. If listing services of exchanges are sufficiently differentiated, then firms benefit from lower listing fees compared to the situation where dual-listing is not allowed. Otherwise firms are worse-off when dual-listing is allowed. Note that when dual-listing is allowed, the discount on listing fees which is used to internalize the cross-network benefit that firms receive is lower compared to the case when dual-listing is not allowed. Therefore we can see dual-listing as a way to soften competition on listing services.

Keywords: Stock exchange, Two-sided markets, Dual-listing, Competition, Trading, Listing

Acknowledgements

First and foremost, I would like to thank Julian Wright for valuable supervision. I would also like to thank particpants of the Industrial Organization seminar in NUS, especially Eko Riyanto. Finally, my education would not have been possible without the support of my family and the Ministry of Foreign Affairs, Singapore. The usual disclaimer applies.

Contents

1 Introduction

Stock exchanges play a crucial role in the economy since they act as platforms that coordinate interaction between firms that need to raise capital, and investors who seek additional investment opportunities. Exchanges provide a venue (either a physical venue or a virtual one) where firms and investors can meet in order to add value to both parties. Furthermore, a well-functioning stock market has positive effects on the overall economy. A wide literature documents the role of stock markets and exchanges in the economy. For example, Beck and Levine (2002) provide empirical evidence that stock markets and banks have a positive influence on economic growth using panel data on 40 countries. More recently, Aghion *et al.* (2004) develop a theoretical model whereby greater financial development leads to convergence to the growth rate of the world technological frontier. They also provide empirical evidence that the likelihood of convergence to U.S. growth rates is positively related to the level of financial development.

As economies become more liberalized and as technology becomes more advanced, stock exchanges are becoming more like competing profit-maximizing firms rather than mere national monopolies (di Noia, 1999; Andersen, 2005). Thus issues related to competition[1] become more relevant. Formulation of sound competition

[1] A recent issue that involves competition policy is the planned and attempted acquisition of the London Stock Exchange by other exchanges including Deutsche Börse, Euronext and even NASDAQ. The U.K. Competition Commission's reports can be accessed at http://www.competition-commission.org.uk/inquiries/ref2005/lse/index.htm. In the U.S., the SEC recently approved the proposed merger of NYSE and Archipelago that consequently transforms the NYSE into a for-profit company.

policy prescriptions necessitates an understanding of how stock exchanges behave in a given market environment. Pricing behavior is one of the important aspects of firm behavior that needs to be examined.

This thesis attempts to model the pricing behavior of stock exchanges under a given set of industrial environments and within a two-sided market framework. The focus is on trading and listing services, and the price level and structure that exchanges will choose for these services. We examine the optimal trading and listing fees that an exchange sets under monopoly and duopoly competition. The focus on these two types of services and the use of the two-sided market framework is motivated by Evans and Schmalensee (2005). They suggest that an appropriate stock exchange model should incorporate important network effects that may limit the scope of competition between exchanges. One of the network effects they briefly discuss is the indirect network effects occurring between firms that issue stocks and investors who trade in these stocks. Firms value investors and at the same time, investors value firms. A stock exchange then serves as a platform to allow these two groups to interact.

An advantage of using a two-sided market framework is that we can explicitly examine the effects of dual-listing (or "multi-homing" as often used in the literature) on the pricing behavior of stock exchanges. Though dual-listing (especially international dual-listing) is not entirely a new phenomenon, there has been a recent interest in domestic dual-listing primarily because of NASDAQ's strategy to attract

NYSE firms to dual-list[2] which could possibly intensify competition between the two major exchanges[3]. Although the model presented in the thesis does not fully capture the *exact* environment under which competition between exchanges occur, our main goal is to provide a simple starting model that can be easily modified, adapted and extended to fit different stock exchange environments.

The scope of the model in the thesis is limited to the special case where trading services from stock exchanges are independent and nonsubstitutable goods. This limitation does not preclude us from having some interesting results. When parameters imply that all firms list in a hypothetical monopolist exchange (covered market), allowing firms to dual-list is harmful for firms since this increases listing fees compared to the situation where dual-listing is not allowed. The intuition behind this result is that when dual-listing is allowed, the decision to list on one exchange does not depend on the decision to list on another and therefore this gives exchanges an artificial monopoly on listing services. When parameters imply that not all firms list in a monopolist exchange (uncovered market), the opposite result holds. Firms now benefit from dual-listing. As will be explained later on[4], this result occurs because listing fees are higher when there is competition compared to when we only have a

[2]NASDAQ announced its dual-listing strategy on 12 Jan 2004, offering zero listing fees in the first year of dual-listing. As of this year, 10 firms (including HP, American Financial Group and Chicago Mercantile Exchange Holdings Inc.) have dual-listed in NASDAQ. For more details, see http://www.nasdaq.com/about/dual-listing/dual-list.stm.

[3]The number of firms that transfered from NASDAQ to NYSE sharply decreased from 51 in 2001 (representing 32% of new listings) to 4 in 2005 (3% of new listings). (The data is from the NYSEData.com website.) Consider this in light of the decision of two firms previously under the dual-listing program to list soley in NASDAQ at the end of 2005.

[4]The result in which monopoly prices are *less* than competitive prices is due to the use of a Hotelling model with exogenous location in our context. Roessler (2006) generalizes this result.

monopoly exchange (in the case of dual-listing, we have artificial local monopolies).

The thesis is developed in the next three sections. A brief survey of the relevant literature is provided in the next section. In section 3, the model is presented and the results are derived. The final section concludes by suggesting possible extensions to the model.

2 Relevant literature

In this section, we briefly survey the literature related to the thesis. This section is divided into three parts. The first part examines what has been done in terms of general modeling of stock exchanges. This literature can be classified as the Industrial Organization approach to modeling stock exchanges since the main focus of this literature is the pricing behavior of exchanges and other competition-related issues such as mergers and alliances. The second strand of literature discusses work done on dual-listing. Most of the papers in this literature are empirical and aim to determine the reasons why firms dual-list on either international or domestic exchanges. The final subsection briefly gives an introduction to the burgeoning literature on two-sided markets.

2.1 IO approach

The paper by Shy and Tarkka (2001) is primarily motivated by the recent public-listing of exchanges and the formation of stock exchange alliances. They create a theoretical model that examines the effects of alliances on the fees that stock exchanges charge to security houses and the fees security houses levy on investors. Based on the model, they conclude that from a welfare perspective, an alliance will be beneficial to the extent that it reduces transaction costs of having to maintain multiple membership on stock exchanges.

Similar to Shy and Tarkka (2001), the paper by Andersen (2005) models stock exchanges as competing profit-maximizing firms. This paper studies the effects of investor-level network externalities (liquidity) via a three-layered spatial model on the investment side (brokers and investors). The model reveals that the monopolist exchange does not internalize this investor-level externality.[5] The reason for this is that every investor will trade in the exchange regardless of the level of fees and hence, the exchange does not have an incentive to provide a discount to increase investor participation. The paper's main result is that a vertically integrated structure (exchange and brokers) leads to lower fees, the greatest demand, and higher profits for brokers.

Both of these papers concentrate on the investors' side and thus consider only half of the whole picture. A paper that attempts to model both the listing and trading side is the paper by Di Noia (1999). This paper explicitly models the direct and cross-network externalities within and among intermediaries (trading side) and firms (listing side). Di Noia (1999) simplifies the analysis by solving for corner-

[5]This is not a general result especially if we allow exchange competition and/or uncovered markets (not all investors will invest).

solutions which is dependent on the assumption that agents are non-atomistic (each agent has significant market influence) and precludes dual-listing and dual-trading. The model is then used to examine the effects of compatibility or implicit mergers. The main conclusion is that exchange competition may lead to inefficient equilibria while cooperation via implicit mergers may be Pareto optimal.

For this thesis, we shall follow Di Noia (1999) by considering exchanges as providing listing and trading services only. However, we shall consider atomistic agents[6] and allow for dual-listing.

2.2 Dual-listing

Much of the empirical literature focuses on the effects of dual-listing on firm valuation and liquidity. Khan *et al.* (1993) provide a brief survey of the empirical literature on domestic dual-listing and observe that there is mixed evidence with respect to the effects of dual-listing on liquidity and firm valuation. They then conduct an event study on firms that are not traded on Unlisted Trading Privileges[7] (UTPs) basis. They conclude that the net effect of domestic dual-listing on returns is negative and infer that corporate managers have other reasons for dual-listing. Nonetheless for international dual-listing, the results seem to point to a positive effect on value as surveyed by McConnell *et al.* (1996).

[6]We shall consider investors which fits more to the atomistic assumption as opposed to non-atomistic intermediaries. We also consider a continuum of firms.

[7]UTPs allow trading of AMEX and NYSE stocks on regional exchanges even if these stocks are not listed on the regional exchange.

Chemmanur and Fulghieri (2001) propose a theoretical model to gain insight on the listing choices of firms and the choice of listing standards by exchanges. They conclude that firms will sole-list in a foreign exchange if the exchange has greater or equal level of transparency compared to the domestic exchange and if investors in the foreign exchange have a comparative advantage in terms of evaluating the firm; and firms will dual-list when they seek to enlarge the base of low cost information producers (investors) of the domestic exchange. Though their model considers investors in the sense that there are low cost and high cost information producers, they ignore investors' trading demand which may affect listing decisions of firms.

2.3 Two-sided markets

A two-sided market is a market characterized by cross-network externalities between two distinct groups of agents. Simply said, one[8] group values the participation of the other group in a two-sided market. An important characteristic of two-sided markets is the presence of a platform that facilitates the interaction between the two sides. A stricter definition of two-sided markets is the one proposed by Rochet and Tirole (2005). They define two-sided markets as markets where the volume of transactions depends on the price structure determined by platforms. A necessary condition for this is that there are factors, whether exogenous (transactions costs) or endogenous (fixed fees) that inhibit agents to negotiate away these cross-network

[8]It is not necessary for both groups to *explicitly* care about the size of the other group for a market to be two-sided. It is possible to have a case with only one-sided network effects but still retain properties and results characteristic of two-sided markets (Armstrong and Wright, 2004).

externalities (Roson, 2005) and therefore, the platform sets prices such that these externalities are internalized.

The two-sided framework has been applied to a wide range of industries[9]. Most of the early application of the two-sided framework came from studies on payment systems (Gans and King, 2003; Katz, 2001; Rochet and Tirole, 2002, Schmalensee, 2002; Wright, 2003a, 2003b, and 2004). Presently, the framework has been applied to competition in media industries (Ferrando *et al.*, 2004; Reisinger, 2004; and Kaiser and Wright, 2004), electronic intermediaries (Caillaud and Jullien, 2003; and Jullien, 2004), and academic journals (Jeon and Rochet, 2006; McCabe and Snyder, 2004, 2005a, and 2005b). So far, none of the current papers on two-sided markets deal with stock exchanges. Nevertheless, Evans and Schmalensee (2005) hint on a possible application of the framework to this industry.

3 Stock exchanges as two-sided networks

To facilitate the modeling of stock exchanges as two-sided networks, we assume that stock exchanges only offer listing and trading services to firms and investors respectively. The main focus will be on firms' listing behavior and the pricing decisions of stock exchanges. We take investors' network benefits from an additional listed firm and an additional investor in the same exchange as negligible. However, total trading revenues that an exchange earns depend on the number of firms and

[9] Most of the citations here are due to Roson (2005).

therefore creates an externality even if no explicit network benefit is assigned. For firms, an explicit network benefit from an additional unit of trading volume will be specified. These two externalities gives our model a two-sided market flavor.

Three situations will be presented. In the first model, we assume that there is only one stock exchange where firms can list and investors can trade. In the second model, we introduce stock exchange competition. We assume that stock exchanges are symmetric in terms of listing and trading cost (c_f and c_t for both exchanges) and search for symmetric equilibria. Furthermore we impose the restriction that firms can only list on a single stock exchange. In the last model, we drop this restriction and allow firms to list on both exchanges.

In general, assume that stock exchange competition is characterized by competition between two stock exchanges, denoted as exchange A and B. Investors divide their income by trading in both exchanges. Moreover, investors invest equal amounts of their income on each stock listed in the exchange. The *per-stock* trading volume in exchange i is defined by $X_i\left(p_t^i, p_t^j\right)$ where p_t^i is the trading fee charged by exchange i for $i = A, B$ and $j \neq i$. Note here that $X_i\left(p_t^i, p_t^j\right)$ does not depend on the number of stocks listed in each exchange. As a start, assume that $\partial X_i / \partial p_t^j = 0$ and $\partial X_i / \partial p_t^i < 0$ which mean investors do not consider the trading services from different stock exchanges as substitutes and demand is decreasing in the exchange's own price.[10] An implication of this assumption is that given the same trading fee charged

[10] A more general model will both consider dependence on the number of listed firms and substitutable trading services. For the purposes of this thesis, I will not model this case and consider this as a subject for future research.

by exchange i, investor demand for trading services of exchange i will remain the same whether this exchange faces competition or not. Moreover, an important limitation of this assumption is that when some firms dual-list, the total network benefit (from trading volume) that these firms receive will double in the symmetric exchange case because investors will trade these stocks in both exchanges. Nonetheless, we adopt this assumption to make our model as simple as possible. A possible interpretation of this assumption is that investors are geographically separated and prefer or are constrained to invest in their "domestic" stock exchange. Thus $X_A\left(p_t^A, p_t^B\right)$ and $X_B\left(p_t^B, p_t^A\right)$ are interpreted not as demand from a single set of investors or a representative investor, but from two geographically separated groups of investors that trade exclusively in A and B. This interpretation will then imply that we are modeling one side of the market as exogenously single-homing (subscribe only to a single platform). However, when we interpret $X_i\left(p_t^i, p_t^j\right)$ as coming from a single set of investors or a representative investor that perceives trading services from each exchange as completely different goods, we actually have a case where the investors' side multi-homes (subscribe to both platforms) since the decision on whether to trade on one exchange is not dependent on the decision to trade on another.[11]

[11]Implicit in this is that the investor is not budget constrained when deciding where to invest.

We specify $X_i\left(p_t^i, p_t^j\right)$ as[12]

$$X_i\left(p_t^i, p_t^j\right) = a - p_t^i$$

for $i = A, B$ and $j \neq i$. For brevity, we suppress the arguments when referring to $X_i\left(p_t^i, p_t^j\right)$.

Assume that firms are uniformly distributed in a unit line as in a standard Hotelling model of spatial competition (Hotelling, 1929; Tirole, 1988, section 7.1) where exchange A is located at the left endpoint while B is located at the right. We treat the location of A and B as fixed and exogenous. The net utility of a firm located at point n from listing in exchange i with listing fee p_f^i is given by $\alpha_f X_i - p_f^i - t_i(n)$ where $t_i(n) = tn$ if $i = A$ and $t_i(n) = t(1-n)$ if $i = B$. The parameter α_f measures the network benefit that a firm receives from every unit of trade in exchange i while t measures how differentiated the two stock exchanges' listing services are (the greater the "transportation" cost[13] t, the higher the degree of differentiation).

We consider a three-stage game where the timing of the game is as follows. At the first stage of the game, stock exchanges simultaneously and independently decide

[12]This specification is a special case of the standard linear exogenous differentiation model (Bowley, 1924). Using the specification in Abito and Wright (2005), the case we consider here is the one where $g = 0$ and $b = 1$.

[13]Transportation cost can be interpreted as having a certain preference for a particular stock exchange. For example, a firm might prefer to list in a domestic exchange since it is more familiar with the types of investors in that exchange and the rules and laws governing it. On the other hand, a firm might prefer to list on a foreign exchange (with greater transparency and stricter disclosure laws) in order to reduce the private benefits of control (Doidge, 2004).

on the listing and trading fees that they will offer to firms and investors. After observing these price offers, firms and investors individually make their decision on where to list and trade. The final stage involves the actual trading of stocks among investors which determine the volume of trade in each stock exchange. In this game, we look for symmetric subgame-perfect equilibria.

3.1 Monopoly stock exchange

In this section we assume that there is only one stock exchange providing trading and listing services. For this case, the monopolist exchange sets optimal trading and listing fees that internalize the externalities present in the market. Trading fees are less than the fees with a pure monopoly markup because the exchange internalizes the positive externality due to network benefits that firms gain from every additional unit of trading volume. Listing fees are also below the pure monopoly fees because the number of listed firms affects *total* trading volume and thus, affects trading profits earned by the exchange as well.

Firms are still distributed uniformly on a unit line and we assume that the location of the monopolist exchange is fixed. Suppose exchange A is the monopolist exchange. A firm located at point n will list in A if and only if $\alpha_f X_A - p_f^A - tn \geq 0$. Taking into account X_A, the number of firms that list on exchange A is therefore given by

$$n^A = \frac{\alpha_f X_A - p_f^A}{t}.$$

An exchange earns its profits from its trading and listing services. Specifically, trading profit is equal to the trading profit margin multiplied by the total trading volume[14] while listing profit is just the listing profit margin multiplied by the number of listed firms. Thus, exchange A will choose the price pair $\left(p_t^A, p_f^A\right)$ that maximizes

$$\Pi_A = \left(\left(p_t^A - c_t\right) X_A + \left(p_f^A - c_f\right)\right) \frac{\alpha_f X_A - p_f^A}{t}$$

subject to[15] $\left(\alpha_f X_A - p_f^A\right)/t \leq 1$. Solving exchange A's optimization problem, equilibrium monopoly prices are given by

$$p_t^A = \frac{a + c_t}{2} - \frac{\alpha_f}{2} \qquad (1)$$

[14] Total trading volume in exchange i is equal to $X_i n^i$.

[15] This constraint ensures that when parameters imply an interior solution for p_f^A that gives strictly positive utility to firms given that all firms list, exchange A will extract all of the firms' surplus by setting a higher listing fee.

and[16]

$$p_f^A = \frac{\alpha_f X_A + c_f}{2} - \frac{\left(p_t^A - c_t\right) X_A}{2} \quad if \quad \left(\frac{a - c_t + \alpha_f}{2}\right)^2 - c_f \leq 2t \qquad (2)$$
$$= \alpha_f X_A - t \quad if \quad \left(\frac{a - c_t + \alpha_f}{2}\right)^2 - c_f > 2t$$

where $X_A = (a - c_t + \alpha_f)/2$.

The effect of two-sidedness is evident in both equations (1) and (2). The optimal trading fee can be decomposed into two parts. The first reflects the standard monopoly price while the second part represents a discount term. The exchange decreases the standard monopoly price in order to internalize the externality due to the network benefit (α_f) that a firm receives per unit of trading volume. The exchange benefits from this reduction in trading fees because it attracts more trading volume which consequently makes the exchange more attractive to firms. Similarly, the optimal listing fee when $((a - c_t + \alpha_f)/2)^2 - c_f \leq 2t$ is composed of the standard monopoly price, less a discount. Note that on top of the basic listing revenue that the exchange earns from firms, the former receives additional revenues via increased trading $(\left(p_t^A - c_t\right) X_A)$ since *total* trading volume is dependent on the number of

[16]Note that

$$\alpha_f X_A - t > \frac{c_f + \alpha_f X_A}{2} - \frac{\left(p_t^A - c_t\right) X_A}{2}$$

if

$$\left(\frac{a - c_t + \alpha_f}{2}\right)^2 - c_f > 2t.$$

We shall see the significance of this condition later on.

firms. Therefore there is an additional benefit from firms that the exchange wants to internalize. When $((a - c_t + \alpha_f)/2)^2 - c_f > 2t$, the exchange can raise its price while still being able to attract all firms to list. Naturally the exchange no longer has an incentive to provide a discount and thus sets a fee such that $\left(\alpha_f X_A - p_f^A\right)/t$ is exactly equal to unity.

Note that if $\alpha_f X_A - p_f^A \geq t$ where p_f^A is defined implicitly and explicitly by equations (1) and (2), then all firms will list in stock exchange A. Otherwise, firms that are "far" from exchange A will decide not to list. This observation is particularly important in our later analysis. We summarize this observation in the following proposition.

Proposition 1 *Given that equilibrium trading and listing fees are defined by equations (1) and (2), all firms will list on stock exchange A (covered market) if*

$$\left(\frac{a - c_t + \alpha_f}{2}\right)^2 - c_f \geq 2t$$

and not all firms will list in exchange A (uncovered market) if

$$\left(\frac{a - c_t + \alpha_f}{2}\right)^2 - c_f < 2t.$$

Proof. Since the set of firms has a unit mass,

$$n^A = \frac{\alpha_f X_A - p_f^A}{t} = 1$$

implies that all firms list on exchange A. This condition holds if parameters satisfy

$$\alpha_f X_A + \left(p_t^A - c_t\right) X_A - c_f \geq 2t$$

which is derived by using the first part of equation (2). Using $X_A = (a - c_t + \alpha_f)/2$ and equation (1), the above inequality finally simplifies to

$$\left(\frac{a - c_t + \alpha_f}{2}\right)^2 - c_f \geq 2t.$$

Similarly, $n^A < 1$ implies that not all firms list on exchange A and therefore the condition

$$\left(\frac{a - c_t + \alpha_f}{2}\right)^2 - c_f < 2t$$

defines an uncovered market. ■

We explore how optimal fees will change once we introduce competition between exchanges in the next section. For the next section, we assume first that dual-listing is not allowed[17]. The section after that explores the effects of dual-listing.

[17] Chinese firms can choose whether to list in the Shanghai Security Exchange or the Shenzhen Security Exchange but dual-listing is not allowed (Shen, 2004; Su, 1999).

3.2 Competing symmetric stock exchanges *without dual-listing*

We consider competition between symmetric stock exchanges when firms can only list on a single exchange. Optimal trading fees are not affected by competition. On the other hand, listing fees can either decrease or increase with the presence of competition depending on whether parameters imply a covered market or not in the monopoly exchange case. Both trading and listing fees still exhibit the discounting due to internalization of positive externalities.

Suppose that exchange A faces competition from another stock exchange (exchange B) with the same costs of providing listing and trading services. We assume that exchange B is located at the rightmost endpoint of the unit line. For this section, we impose the restriction that firms can only list on a single exchange.

A firm located at point n will list in exchange A as opposed to B if and only if $\alpha_f X_A - p_f^A - tn \geq \alpha_f X_B - p_f^B - t(1-n)$ and $\alpha_f X_A - p_f^A - tn \geq 0$. The indifferent firm can be identified by solving $\alpha_f X_A - p_f^A - t\overline{n} = \alpha_f X_B - p_f^B - t(1-\overline{n})$ for $\overline{n}$. Firms located in $n < \overline{n}$ will list in exchange A while the rest will list in exchange B given that all the firms receive nonnegative utility. Therefore the number of firms that would list in i is given by

$$n^i = \frac{1}{2} + \frac{\alpha_f (X_i - X_j) - \left(p_f^i - p_f^j\right)}{2t}$$

for $i = A, B$ and $j \neq i$ given $\alpha_f X_i - p_f^i - t_i(n) \geq 0$.

Exchange i's problem is to choose the price pair $\left(p_t^i, p_f^i\right)$ that maximizes[18]

$$\Pi_i = \left(\left(p_t^i - c_t\right) X_i + \left(p_f^i - c_f\right)\right)\left(\frac{1}{2} + \frac{\alpha_f \left(X_i - X_j\right) - \left(p_f^i - p_f^j\right)}{2t}\right).$$

Solving exchange i's maximization problem, the symmetric equilibrium is characterized by

$$p_t^i = \frac{a + c_t}{2} - \frac{\alpha_f}{2} \tag{3}$$

and

$$p_f^i = c_f + t - \left(p_t^i - c_t\right) X_i \tag{4}$$

for $i = A, B$.

The equilibrium trading fee is the same as equation (1). This is a natural implication of our assumption on X_i. Since both exchanges have an exclusive set of investors, competition between exchanges does not affect how they set trading fees. A further decrease from the trading fee given by equation (1) does not make the exchange more attractive *relative* to the other exchange since trading demand in the other exchange is not affected by this reduction in trading fees. With regards to the listing fees, we cannot clearly see whether listing fees are now lower compared to the monopoly exchange case. In fact, we shall show later that this depends on whether

[18]In this case, we assume that in equilibrium, parameters satisfy $\alpha_f X_i - p_f^i - t_i\left(n\right) \geq 0$.

parameters satisfy a covered market in the monopoly case or not. Nonetheless, equation (4) is still subject to the discounting that we observed in the monopoly exchange case. To see this, note that equation (4) has two parts. The first part $(c_f + t)$ is the normal Hotelling price while the other part $((p_t^i - c_t) X_i)$ reflects the internalization of the positive externality caused by an additional listed firm. It is interesting to note that the discount due to the externality is now greater compared to the monopoly exchange case.

As mentioned previously, when we interpret X_i as the demand of a single set of investors or a representative investor, the implication is that the investors' side is multi-homing. Thus we have a case where one side (investors) is multi-homing while the other (firms) is single-homing. This seems to be analogous to the competitive bottleneck case in Armstrong (2005, section 5). In the competitive bottleneck case, platforms compete aggressively to attract single-homing agents while extracting the surplus of agents that multi-home. Therefore, the competitive bottleneck case predicts that when compared to the monopoly exchange case, competing exchanges will charge the same trading fee while listing fees will be lower. This result is true if parameters imply a covered market in the monopoly exchange case. If parameters imply an uncovered market, then the listing fee in the monopoly exchange case is lower than the listing fee when there is competition[19] between exchanges and thus the competitive bottleneck result does not *seem* to hold. Nonetheless as

[19] The phenomenon whereby rivalry can increase prices was recently observed by Roessler (2006) and Sanner (2005).

mentioned previously, the discount due to the externality is still greater in the case of competition. The reason why the competition listing fee is greater than in the monopoly exchange case is not due to network effects or other externalities. Rather, it is a consequence of using the Hotelling model. Therefore the competitive bottleneck result, in essence, still holds. If we interpret investors as single-homing agents, then the larger discount on listing fees reflect the fact that competition for firms is more fierce compared to competition for investors (which is currently assumed to be nonexistent). This observation is consistent with Armstrong (2005, section 4). The following proposition summarizes these results.

Proposition 2 *Assuming firms cannot dual-list, equilibrium listing fees are lower with exchange competition if*

$$\left(\frac{a - c_t + \alpha_f}{2}\right)^2 - c_f \geq 2t. \qquad \text{(Covered market)}$$

If

$$\left(\frac{a - c_t + \alpha_f}{2}\right)^2 - c_f < 2t, \qquad \text{(Uncovered market)}$$

then listing fees are higher when there is exchange competition.

The discount on listing fees is higher with competition than in the monopoly case.

Proof. Listing fees in the monopoly exchange case is higher than the competition case if

$$\frac{\alpha_f X_i + c_f}{2} - \frac{(p_t^i - c_t) X_i}{2} \geq c_f + t - \left(p_t^i - c_t\right) X_i$$

where p_t^i is given by equation (3) and $X_i = (a - c_t + \alpha_f)/2$. The above simplifies to

$$\alpha_f X_i + \left(p_t^i - c_t\right) X_i - c_f \geq 2t$$

and therefore is satisfied by

$$\left(\frac{a - c_t + \alpha_f}{2}\right)^2 - c_f \geq 2t.$$

Finally, if

$$\left(\frac{a - c_t + \alpha_f}{2}\right)^2 - c_f < 2t,$$

then

$$\frac{\alpha_f X_i + c_f}{2} - \frac{(p_t^i - c_t) X_i}{2} < c_f + t - \left(p_t^i - c_t\right) X_i$$

and thus listing fees in the competition case is higher than the monopoly exchange case.

Note that the discount on listing fees when there is exchange competition is

$(p_t^i - c_t) X_i$ while only half of this amounts to the discount in the monopoly exchange case when $((a - c_t + \alpha_f)/2)^2 - c_f \leq 2t$. When $((a - c_t + \alpha_f)/2)^2 - c_f > 2t$, a monopolist exchange does not provide a discount on listing fees. ■

With exchange competition, we can interpret the parameter conditions for a covered or uncovered market as conditions on the degree of differentiation of listing services. If listing services of exchanges are sufficiently differentiated (t is large enough), then we have an uncovered market. Otherwise we have a covered market. The results of Proposition 2 will thus depend on the degree of differentiation of listing services.

In the next section, we allow firms to list on both exchanges. As we will see, the effect of dual-listing is to give exchanges an artificial monopoly on firms that are relatively "near" to them.

3.3 Competing symmetric stock exchanges *with dual-listing*

In this section, we allow firms to list on both exchanges. While trading fees remain the same as in the previous two cases, listing fees now revert back to the monopoly exchange case even if there is exchange competition. The intuition is simple. If we abstract from firms' budget constraints, the decision to list in one exchange is essentially independent of the decision to list in the other. More precisely, the decision to list in exchange i depends on whether the firm will receive nonnegative utility from listing in i and not on whether the utility from listing in i is greater than the utility from listing in j. Therefore, both exchanges have local monopolies on the firms located "near" to them.

Formally, firms previously listed only in exchange j will dual-list if[20]

$$\alpha_f X_i - p_f^i - t_i(n) + \alpha_f X_j - p_f^j - t_j(n) \geq \alpha_f X_j - p_f^j - t_j(n)$$

which simplifies to $\alpha_f X_i - p_f^i - t_i(n) \geq 0$. Therefore, dual-listing firms are those firms that receive nonnegative utility from listing in exchange i but prefer listing in exchange j when dual-listing is not allowed. Let n^* be the solution to $\alpha_f X_i - p_f^i - t_i(n^*) \geq 0$. Notice that the implied n^* is the same listing demand that a monopolist exchange faces. Let n_S^i be the number of firms that list exclusively in exchange i when dual-listing is allowed and let n_M be the number of firms that list on both exchanges. It follows that $n_M = n^* - n_S^i$. The total number of firms listed in exchange i will then be given by $n_S^i + n_M = n^*$. Since n^* is the listing demand faced by a monopolist exchange, both exchanges essentially act as if they have local monopolies on listing services. Therefore exchange i solves the same optimization problem as the monopolist exchange and hence charges the same level of trading and listing fees (equations (1) and (2)).

Dual-listing can thus have two opposing effects depending on whether the parameters lead to a covered market or not. Based on Proposition 2, if we have a covered market, dual-listing is detrimental for firms in the sense that it increases listing fees. Otherwise, firms benefit from dual-listing when we have an uncovered

[20]Implicit here is the condition that $\alpha_f X_j - p_f^j - t_j(n) \geq \alpha_f X_i - p_f^i - t_i(n)$.

market since listing fees are now reduced. Note that in both cases, the discount on listing fees is lower when dual-listing is allowed.

Proposition 3 *When dual-listing is allowed, listing fees are higher relative to the case when dual-listing is not allowed if*

$$\left(\frac{a - c_t + \alpha_f}{2}\right)^2 - c_f \geq 2t. \qquad \text{(Covered market)}$$

Listing fees are less relative to the no dual-listing case if

$$\left(\frac{a - c_t + \alpha_f}{2}\right)^2 - c_f < 2t. \qquad \text{(Uncovered market)}$$

The discount on listing fees is lower when dual-listing is allowed for both cases.

Proof. This is a direct consequence of Proposition 2 and the fact that exchanges solve the same optimization problem as a monopolist exchange. ■

It is interesting to note that with a covered market, all firms will actually dual-list. To see this, observe that with a covered market, n^* equals unity for both exchanges. This means that all firms satisfy the incentive constraint for dual-listing. Therefore $n_S^i = 0$ and $n_M = n^* = 1$. With this result, it seems that having an uncovered market is more consistent with reality since not all firms actually dual-list. However, some results in this thesis might not hold since we abstracted from competition to attract investors. It remains to be seen what happens in this case.

It is possible to have a case where $n_M = 0$. This occurs when $n^* = n_S^i \leq 1/2$

in the symmetric exchange case. Thus in order to have some dual-listing firms, exchanges should be able to discriminate between firms that are willing to list in them at the current prices (given by equation (2)) and those that are not willing. An exchange can easily observe this after some time since it can observe where firms eventually list. It can then target the firms listed on the other exchange, offer them much lower fees, and eventually attract them to dual-list.

4 Conclusion

We have created a simple model of stock exchange competition based on the two-sided market framework. We have shown that dual-listing can either increase or decrease listing fees, depending on how differentiated the listing services of exchanges are. If listing services of exchanges are sufficiently differentiated, then firms benefit from lower listing fees when dual-listing is allowed. On the other hand, if t is sufficiently small, then firms are worse-off when dual-listing is allowed since listing fees are now higher. Also note that when dual-listing is allowed, the discount on listing fees which is used to internalize the cross-network benefit that firms receive is lower compared to the case when dual-listing is not allowed. Therefore we can see dual-listing as a way to soften competition on listing services.

The model in this thesis is limited to the case where investors perceive trading services of exchanges as independent and nonsubstitutable goods. An obvious extension is to model trading demand using the standard linear exogenous differentiation model (Bowley, 1924). Furthermore, we can endogenize the location of exchanges which can intensify competition. Also, the peculiar result of increased prices with competition might be remedied when we allow exchanges to choose their position in the unit line. Lastly, we can incorporate liquidity in the model by specifying trading demand as positively related to the number of investors.

5 References

Abito, J. M. and J. Wright (2005), "Exclusive Dealing with Imperfect Downstream Competition," *mimeo*, National University of Singapore.

Aghion, P., P. Howitt and D. Mayer-Foulkes (2004), "The Effect of Financial Development on Convergence: Theory and Evidence," NBER Working Paper 10358.

Andersen, A. (2005), "Pricing of Stock Exchange Trading – The Role of Network Externalities," PhD Thesis, Helsinki School of Economics.

Armstrong, M. (2005), "Competition in Two-Sided Markets," *RAND Journal of Economics*, forthcoming.

Armstrong, M. and J. Wright (2004), "Two-sided markets, competitive bottlenecks and exclusive contracts," *eo*, University College London and National University of Singapore.

Beck, T. and R. Levine (2002), "Stock Markets, Banks, and Growth: Panel Evidence," NBER Working Paper 9082.

Bowley, A. L. (1924), *The Mathematical Groundwork of Economics,* Oxford: Oxford University Press.

Caillaud, B. and B. Jullien (2003), "Chicken & egg: Competition among intermediation service providers," *RAND Journal of Economics*, 24: 309-328.

Chemmanur, T. and P. Fulghieri (2001), "Choosing an Exchange to List Equity: A Theory of Dual-Listing , Listing Requirements, and Competition among Exchanges," *mimeo*, Boston College and INSEAD.

Di Noia, C. (1999), "The Stock-Exchange Industry: Network Effects, Implicit Mergers and Corporate Governance," *Quaderni di Finanza*, 33.

Doidge, C. (2004), "U.S. Cross-Listings and the Private Benefits of Control: Evidence from Dual-Class Firms," *Journal of Financial Economics*, 72: 519-553.

Evans, D. and R. Schmalensee (2005), "The Industrial Organization of Markets with Two-Sided Platforms," NBER Working Paper 11603.

Ferrando, J., J. J. Gabszewicz, D. Laussel and N. Sonnac (2004), "Two-Sided Network Effects and Competition: An Application to Media Industries," *mimeo*, CREST-LEI and EUREQUA CORE, Université Catholique de Louvain GREQAM, Université de la Méditerranée CREST-LEI and Université de Paris II.

Gans, J. S. and S. P. King (2003), "The Neutrality of the Interchange Fees in the Payment," System, *Topics in Economic Analysis & Politics*, 3, Article 1.

Hotelling, H. (1929), "Stability in Competition," *Economic Journal*, 39(1): 41-57.

Jeon, D. and J. Rochet (2006), "The Pricing of Academic Journals: A Two-Sided Market Perspective," *mimeo*, Universitat Pompeu Fabra, CREA, Université de Toulouse and IDEI.

Jullien, B. (2004), "Two-Sided Markets and Electronic Intermediaries," CESifo Working Paper 1345.

Kaiser, U. and J. Wright, (2004), "Price Structure in Two-Sided Markets: Evidence from the Magazine Industry," *International Journal of Industrial Organization*, 24: 1-28.

Katz, M. L. (2001), *Reform of Credit Card Schemes in Australia II,* Sydney: Reserve Bank of Australia.

Khan, W., H. Baker, R. Kennedy and L Perry (1993), "Dual Domestic Listing, Market Structure and Shareholder Wealth," *Financial Review*, 28: 371-383.

McCabe, M. J. and C. Snyder (2004), "The Economics of Open-Access Journals," *mimeo*, Georgia Institute of Technology and George Washington University.

McCabe, M. J. and C. Snyder (2005a), "A Model of Academic Journal Quality and Applications to Open-Access Journals," *mimeo*, Georgia Institute of Technology and George Washington University.

McCabe, M. J. and C. Snyder (2005b), "Open-Access and Academic Journal Quality," *American Economic Review, Papers and Proceedings*, 95(2): 453-458.

McConnell, J., H. Dybevik, D. Haushalter and E. Lie (1996), "A Survey of Evidence on Domestic and International Stock Exchange Listings with Implications for Markets and Managers," *Pacific-Basin Finance Journal*, 4: 347-376.

Reisinger, M. (2004), "Two-Sided Markets with Negative Externalities," Discussion Paper 2004-27, University of Munich.

Rochet, J. and J. Tirole (2002), "Cooperation among Competitors: The Economics of Payment Card Associations," *RAND Journal of Economics*, 33: 549-570.

Rochet, J. and J. Tirole (2005), "Two-Sided Markets: A Progress Report," *RAND Journal of Economics*, forthcoming.

Roessler, C. (2006), "Can Rivalry Increase Prices?" *mimeo*, University of Melbourne.

Roson (2005), "Two-Sided Markets: A Tentative Survey," *Review of Network Economics*, 4: 142-160

Sanner, H. (2005), "Price Responses to Market Entry with and without Endogenous Product Choice," Discussion Paper 81, University of Potsdam.

Schmalensee, R. (2002), "Payment Systems and Interchange Fees, *Journal of Industrial Economics*, 50: 103-122.

Shen, T. (2004), "The Regulation of Stock Trading and its Enforcement in China," MA Thesis, University of Konstanz.

Shy, O. and J. Tarkka (2001), "Stock Exchange Alliances, Access Fees and Competition," Bank of Finland Discussion Papers 22/2001.

Su, D. (1999), "Ownership Restrictions and Stock Prices: Evidence from Chinese Markets," *The Financial Review*, 34: 37-56.

Tirole (1988), *The Theory of Industrial Organization*, Cambridge: MIT Press.

Wright, J. (2003a), "Optimal Card Payment Systems," *European Economic Review*, 47: 587-612.

Wright, J. (2003b), "Pricing in Debit and Credit Card Schemes" *Economics Letters*, 80: 305-309.

Wright, J. (2004), "One-sided Logic in Two-Sided Markets," *Review of Network Economics*, 3: 44-64.