Stock Exchange Competition in a Simple Model of Capital Market Equilibrium

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Abstract

This paper uses a simple model of mean-variance asset pricing with transactions costs to analyze one of the main empirical phenomena in stock market competition in the last years, the decrease of transaction costs. We endogenize transactions costs as variables strategically influenced by stock exchanges and model stock market integration as an increase in the correlation of the underlying market returns. Among other things, we find that market integration leads to a decrease of transaction costs and to an increase in long-term trading activity.

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1 Introduction

The objective of this paper is to analyze the competition between stock exchanges in the framework of asset pricing theory. We do this by considering a simple mean-variance capital market equilibrium model with transactions costs and by endogenizing the transactions costs as variables strategically influenced by stock exchanges. This perspective integrates insights from the asset pricing and the industrial organization literature and thus brings together two approaches to the study of stock exchanges that have evolved largely independently up to now.

We use this framework to investigate the determinants of transactions costs and trading volume for competing stock exchanges. Starting in the mid-1980s with the London Stock Exchange, European stock exchanges began a process of liberalization, which led to more profit-oriented exchange organizations and strategies across Europe, and ultimately to serious competition between European stock markets. With the advent of cross-listings of European firms on the NYSE and Nasdaq and the continuing debate of the optimal trading structure of the American exchanges, this competition went global in the 1990s.[1]

Up to now, the literature has analyzed competition between stock exchanges as competition for the listing of firms (prominent examples of this literature are Angel and Aggarwal (1997), Chemmanur and Fulghieri (1999), Foucault and Parlour (2004), and Huddart, Hughes and Brunnermeier (1999)). While this type of competition exists for some large firms and has become more important in the 1990s (see Pagano, Roell, and Zechner (2002)), Table I shows that it does not apply to the large majority of listed firms around the globe: most firms list on a local stock exchange and nowhere else. In fact, in 2002 the only major European stock exchange with large foreign turnover was London. Table I also shows that while the share of foreign firms listed on some stock exchange can reach 35 % of total listings in numbers (in Switzerland), the total value of foreign share trading on all exchanges (except London) is negligible.

[1] See, for example, McKinsey-JPMorgan (2002)

Table I
Value of Shares Traded and Number of Companies Listed for Selected Stock Exchanges

Note: Data for 2002, main and parallel markets. Remaining percentages are investment funds. Source: World Federation of Exchanges.

	Total Value of Trading		Number of Listed Comp.	
	Domestic	Foreign	Domestic	Foreign
Euronext	98%	1%	1114	N.A.
Frankfurt	92%	8%	715	219
Hong Kong	100%	0%	968	10
Milan	91%	9%	288	7
London	47%	53%	1890	382
Nasdaq	96%	3%	3268	381
NYSE	91%	7%	1894	472
Madrid	99%	1%	2986	29
Tokyo	99%	0%	2119	34
Zurich	97%	2%	258	140

In this paper, we therefore model stock exchange competition as competition for investors rather than for firms. In line with the figures suggested by Table I, we view stock exchanges as trading platforms for local assets and analyze the behavior of investors who diversify their portfolios across those assets. Stock exchanges charge fees and commissions to profit from this trading. High fees benefit stock exchanges directly, but hurt them indirectly because they distort investors' portfolio choices away from the assets traded on that exchange. The optimal fee size balances these two effects, just as in a standard oligopoly model in Industrial Organization. What is new in our work is that we explicitly derive investors' trades in a capital markets model with transactions costs.[2] In fact, as far as we know, our model is the first to provide an explicit solution to a general equilibrium asset pricing model with more than one risky asset and proportional transactions costs. We obtain this solution because we consider a static model with a simple specification: normally distributed returns, exponential utility, and two types of investors

[2] Shy and Tarkka (2001) also endogenize brokerage fees, but in a model with exogenous trading demand.

(distinguished by their endowments). Nevertheless, even in this simple framework the solution becomes somewhat complicated and has some surprising features.

The most surprising feature of the asset market equilibrium is that in equilibrium those investors who have the largest exposure to one asset still can be net buyers of this asset. In particular, the home bias of local investors may be reinforced by trading under transactions costs. This happens although the only motive for trade in our model are endowment differentials. Hence, without transactions costs trading would result in an equalization of asset holdings across investors, and owners of large quantities would sell. In the presence of transactions costs, however, an investor may buy more of an asset to which she is already strongly exposed because this may allow her to buy less of another asset for which trading costs are relatively higher. In particular, depending on the covariance structure of asset returns, transactions costs for the trading of one asset can have perverse effects on the trading of others.

With this asset market equilibrium at our disposal, we can study the optimal fee policy of stock exchanges. We assume that stock exchanges set trading fees to maximize the revenues from trading that accrue to themselves and their members. In fact, we interpret stock exchanges broadly as a coalition of traders that intermediate stock transactions and therefore we count as fees not only the direct trading fees payable to the exchange, but also the brokerage fees, trading commissions, and other revenues of the assigned dealers at the exchange from executing trades. We do this because exchanges are usually controlled by their members, and their trading revenue critically depends on the exchange's policies.[3] Table II provides international evidence on stock exchange transactions costs, which include some measures of illiquidity and market impact costs. To put these figures in perspective, it is useful to remember that in 1998 the revenue from transactions services at the NYSE alone was \$165 million.[4]

[3] See Foucault and Parlour (2004), Domowitz, Glen and Madhavan (2001), and McKinsey-JPMorgan (2002) for more discussion, institutional examples, and numbers.

[4] This represented 23% of the NYSE's total revenue. The remaining \$552 million came from listing fees and sale of data (which we ignore in this analysis, and from clearing and settlement services, which are strongly correlated with transactions services. The corresponding data for Nasdaq were: revenues from transactions services \$127 million, out of a total of \$705 million (Source: Foucault and Parlour (2004)).

Table II
One-Way Transactions Costs for Trading Stock in Selected Countries

Data for 2001, 1st quarter, in basis points. Direct costs: Commissions, trading, clearing, and other transactions fees. Indirect costs: Price impact of trade and also one-half of the bid- ask spread according to Domowitz, Glen and Madhavan (2000, 2001).U.K.: Average of buy and sell orders. Source: Elkins/McSherry.

	Direct	Indirect	Total
Belgium	19.9	7.2	27.1
Canada	17.2	29.5	46.7
Finland	22.6	22.6	45.2
France	22.0	13.8	35.8
Germany	21.6	8.9	30.5
Italy	23.2	17.8	41.0
Japan	14.7	4.7	19.4
Netherlands	21.3	3.1	24.4
Spain	23.9	15.3	39.2
Sweden	21.8	11.1	32.9
Switzerland	26.0	12.6	38.6
UK	42.0	8.3	50.3
NYSE	14.3	14.9	29.2
US OTC	2.4	34.2	36.6

We find that in equilibrium, stronger market integration, as measured by an increase in the covariance of local asset returns, leads to a decrease in transactions costs. This effect mainly stems from the decreasing demand for international diversification by investors, which erodes foreign exchanges' market power, and is consistent with the recent trend in Europe away from cross-country allocation strategies and towards industry-based allocation strategies.[5] Similarly, we predict that stock exchanges of markets that are less well integrated with the rest of the world should have higher transactions costs, which is consistent with the international comparative data provided by Domowitz, Glenn and Madhavan (2001).

[5]See Galati and Tsatsaronis (2001) and Adjaoute and Danthine (2003).

We further find that equilibrium fees depend negatively on exogenous trading costs (trading costs that cannot be directly set by the stock exchange). Hence, exchanges have an interest in setting rules and using technology that lower these costs. This is, of course, exactly what has happened in the last 10 - 20 years in stock exchanges around the world: exchanges have adopted automated trading mechanisms, improved clearing and settlement procedures, and implemented trading rules that reduce trading costs. This has made these exchanges more attractive and allowed them to reduce trading fees less than they would have otherwise been forced to.[6]

Our work also allows to distinguish short-run from long-run phenomena. Trading volumes are a case in point. We show that in the short run an increase in international return correlations leads to reduced trading, which is intuitive because increased correlation reduces hedging demand from investors. However, in Europe in the 1990s the trend has been one of increasing correlation and *increasing* trading volumes. While this may also be due to factors outside our model, such as increased spillovers in real activity, our model is consistent with this observation. In fact, the model predicts that in the longer run, transactions costs adjust to accommodate the decreased hedging demand of investors, which in turn stimulates cross-border portfolio investment. As we show, this indirect effect overcompensates the direct effect, leading to an overall increase in trading volumes.

Two branches of the literature are close related to this paper: general equilibrium models of asset pricing under transaction costs and models of exchange competition. As mentioned above, the latter literature mainly studies competition for the listing of firms or the trading of securities between different exchanges and thus has a different focus than our work. Relevant issues in that context are economies of scale in trading (Doede (1967) and Demsetz (1968)), liquidity effects (Pagano (1989) and Glosten (1994)), transportation costs (Gehrig (1998)), economies of scope (Pirrong (1999), and network externalities (Di Noia (2001).

The asset pricing literature has up to now mostly focused on models with one risky asset and one riskless asset. Building on the continuous-time analyses of portfolio choice of Constantinides (1979) and Taksar, Klass, and Assaf (1983), Constantinides (1986) has analyzed equilibrium under proportional transactions costs and finds that while the impact of transactions costs on

[6] Domowitz (2001) estimates that, all other things equal, average trading costs are lower by 33-46% bps in markets that are largely automated.

trading behavior (characterized by a "no-trade region" in endowment space) can be substantial, the impact on asset returns is small, due to adjustments in dynamic trading strategies. Basak and Cuoco (1998) have analyzed equilibrium in a market in which one group of investors is excluded from trading the (one) risky asset, which can be viewed as the limiting case of infinite transactions costs. Recently, progress has been made in the study of portfolio problems with several risky assets (see, in particular, Leland (2000) and Liu (2004)), but this work does not analyze market equilibrium. The few papers that study markets with several assets under transactions costs typically assume "variable proportional costs", i.e. transactions costs that are effectively quadratic in the quantity traded.[7] This has the advantage that transactions costs are a second-order effect for small trades and thus that Constantinides' no-trade region disappears. If one is interested in the impact of transactions costs on trading activity, the full first-order effect is, however, important and (constant) proportional costs should not be ignored.

The rest of the paper is organized as follows: Section 2 sets out the model. Section 3 describes the equilibrium in the asset market and Section 4 the optimal behavior of stock exchanges. Section 5 delivers the main comparative statics results and their interpretation, and Section 6 concludes. One longer proof is in the appendix.

2 The Model

The model considers two countries, $i = 1, 2$, with the same currency (i.e. we ignore exchange rate risk). For each country there is one risky asset and one riskless asset. We interpret the risky asset as a representative asset of the economy, similar to a stock market index.[8] The riskless asset has a gross return normalized to 1 in both countries. Shares of risky assets (stocks) are perfectly divisible and are in positive supply ($s_i > 0, i = 1, 2$). There is one round of asset trading and pricing in this model. Let p_i be the price of risky asset i and $\widetilde{F}_i$ its payoff at the end of the period. The (2×1) vector of payoffs

[7] See, e.g., Brennan and Subrahmanyam (1996) or Fernando (2003).

[8] As discussed in the introduction, we do not consider competition between stock exchanges for the listing of international stocks. Although this is of some importance for some stocks (such as Nokia or Siemens), it is of little relevance for the large majoritiy of stocks and exchanges. This type of competition is largely orthogonal to the problem studied in this paper.

$\widetilde{F}$ is normally distributed with mean μ and variance

$$\Sigma = \begin{pmatrix} \sigma_1^2 & \sigma_{12} \\ \sigma_{12} & \sigma_2^2 \end{pmatrix}$$

As usual, we denote by $|\Sigma| = \sigma_1^2\sigma_2^2 - \sigma_{12}^2$ the determinant of Σ, and by $\rho = \sigma_{12}/(\sigma_1\sigma_2)$ the correlation coefficient. There is a continuum of mass 1 of investors located in the two countries who are identical except for their initial endowments. Investors in country j ("type j investors") hold the amount e_i^j of asset i per capita. The total mass of type-j investors is ω^j ($\omega^1 + \omega^2 = 1$), hence total asset supply is $s_i = \sum_j \omega^j e_i^j$, $i = 1, 2$. We denote the difference of endowments for asset i between investor type 1 and 2 by

$$\Delta_i \equiv e_i^1 - e_i^2. \tag{1}$$

Thus investor type 1 owns more of asset i per capita than investor type 2 iff $\Delta_i > 0$ (but the total amount of asset i in the hands of 1-investors, $\omega^1 e_i^1$, may be smaller than the total amount in the hand of 2-investors).

Table III
Share Ownership Structure of Listed Companies for Various Countries

Data for end 2000, in percent. Source: Guiso, Halassios and Japelli (2002).

	France	Germany	Italy	Netherlands	Sweden	UK	US
Foreign	36.5	19.9	15.7	43.6	38.9	29.2	6.4
Domestic	63.5	80.1	84.3	65.5	61.1	70.7	93.6

Hence, for each asset there is a larger investor and a smaller investor. It is well known that in practice domestic investors hold more of the local assets than foreign investors. Table III provides some data illustrating this "home bias". We therefore focus on this constellation[9] and assume

$$\Delta_1 > 0, \Delta_2 < 0.$$

[9] The analysis can easily be generalized to groups of investors who are not differentiated by their country of residence but by other criteria. For example, we have also analyzed the case of two types of investors, $j = A, B$, where investor j has an initial endowment $e^j = (e_1^j, e_2^j)'$ of the two risky assets, with $\Delta_1 = e_1^A - e_1^B > 0$ and $\Delta_2 > 0$ (investor A is large in both markets). This specification is less convincing descriptively in the context of stock market competition.

Each investor has initial wealth W_0 and exponential utility with coefficient of absolute risk aversion $\theta > 0$. Investors maximize expected utility from final wealth $\widetilde{W}^j$. They can trade assets incurring a proportional transaction cost $T = (T_1, T_2)'$ in the two assets, and borrowing and short selling is allowed. Denoting the amount of asset i bought by investor j by $t_i^j \in \mathbb{R}$, final wealth is

$$\widetilde{W}^j = W_0 + e^j \cdot \widetilde{F} + t^j \cdot \left(\widetilde{F} - p\right) - \left(\delta^j t^j\right) \cdot T \tag{2}$$

where

$$\delta^j = \begin{pmatrix} \text{sign}\ (t_1^j) & 0 \\ 0 & \text{sign}\ (t_2^j) \end{pmatrix}$$

is a diagonal 2×2 matrix indicating the directions of trade.[10] Because there is only trade between investors of different type, we can simply denote $\delta = \delta^1 = -\delta^2$. By the normality assumption, preferences are in fact mean-variance, and investor j solves the following problem:

$$\max_{t^j} \Phi(t^j; p, T) \equiv E\widetilde{W}^j - \frac{1}{2}\theta var \widetilde{W}^j \tag{3}$$

For each asset, there is one exchange (which we interpret as the national stock exchange) on which the asset can be traded. Transactions costs consist of two components, $T_i = f_i + d_i$, where f_i are fees and d_i other transactions costs, such as taxes, communication costs, and liquidity costs. As we do not model the stock exchanges' market micro structure, we interpret the stock exchange broadly as a group of actors intermediating the trade of a given set of stocks and interpret the f_i as comprising market maker and brokerage fees as well as direct stock exchange fees. While the other costs d_i are exogenous, exchanges (broadly interpreted) determine their fees f_i in order to maximize profits. These fees represent a transfer from investors to stock exchanges.

Therefore, total returns to stock exchange i are $f_i \sum_j \omega^j \left|t_i^j\right| = 2 f_i \omega^1 \left|t_i^1\right|$, where $\omega^j \left|t_i^j\right|$ is total trade in asset i by investor class j. This assumes that both sellers and buyers pay the cost T_i. An alternative would be to consider a fee on trading volume, which would give half of the figure above. The profit of exchange i then is

$$\pi_i = 2\omega^1 \left|t_i^1\right| (f_i - c_i) - K_i \tag{4}$$

[10] As usual, x' denotes the transpose of vector x and $x \cdot y$ the scalar product of x and y.

where c_i is a constant unit cost of intermediating trade and K_i a fixed cost. For simplicity, we set $K_i = 0$. Exchange i chooses f_i such as to maximize π_i.

Stock exchange competition is modeled as a normal-form game. The two players are the two exchanges, their strategies are $f_i \in [0, \infty)$, and their payoff functions are the profit functions π_i as defined in (4). In making their decisions, stock exchanges rationally anticipate investor behavior t^j. The overall game has two stages and complete information, since the stock exchanges are assumed to know investors' preferences and endowments. To solve the game we use backwards induction. In the second stage, investors make investment decisions, taking transactions costs as given. In the first round exchanges simultaneously choose f_i, and we look for a Nash equilibrium in these choices.

3 Equilibrium in the asset market

In this section, we study equilibrium in the asset market, taking the decisions of stock exchanges as given. This analysis will then be folded back into the study of the equilibria of the competition between stock exchanges in the next section. To simplify some formulas, we restrict attention to the case of positive correlation, $\rho \geq 0$.

3.1 Ignoring transaction costs

As a benchmark it is useful to remember the solution of the portfolio problem when there are no transaction costs. Individual asset demand is

$$t_i^j = -e_i^j + \frac{1}{\theta |\Sigma|} \left(\sigma_l^2 \left(\mu_i - p_i \right) - \sigma_{12} \left(\mu_l - p_l \right) \right), l \neq i. \tag{5}$$

Optimal trading increases with the expected return and decrease with variance and risk aversion. The impact of the parameters of the other asset depends on the covariance, which reflects the investors' diversification motive. The covariance-term in (5) can be seen as a hedging term, whose function is to reduce the global risk of the portfolio.

The market clearing condition is

$$0 = \omega_i^1 t_i^1 + \omega_i^2 t_i^2, \forall i, \tag{6}$$

which yields the equilibrium price

$$p_i = \mu_i - \theta\sigma_i^2 s_i - \theta\sigma_{12} s_l, l \neq i. \tag{7}$$

Prices depend positively on expected payoffs and negatively on the variance and risk aversion. They are affected negatively by the supply of both assets since assets are partial complements. The higher the covariance, the lower the price. In equilibrium, agent 1's trade is

$$t_i^1 = -\omega^2 \Delta_i, \forall i. \tag{8}$$

Hence, trade in an asset is simply negatively proportional to the investor's relative position in the asset, Δ_i (see (1)). The group of investors with large endowments ($\Delta_i > 0$) sell the asset while the group of investors with small endowments ($\Delta_i < 0$) buy. After one round of trading without transactions costs the home bias disappears, and both types of investors hold $\omega^1 e_i^1 + \omega^2 e_i^2$ of each asset.

3.2 Portfolio choice and equilibrium with transaction costs

We now turn to the main issue of the paper, and begin by analyzing the investors' portfolio problem under transactions costs. Investor j's objective function (3) written out is

$$\Phi(t^j; p, T) = W_0 + e^j \cdot \mu + t^j \cdot (\mu - p) - (\left|t_1^j\right|, \left|t_2^j\right|)T - \frac{1}{2}\theta var((e^j + t^j) \cdot \widetilde{F}).$$

Multiplying out the variance term and introducing the function $\Psi(t^j; p, T) \equiv \Phi(t^j; p, T) - \Phi(0; p, T)$ to get rid of constants, we have

$$\Psi(t^j; p, T) = A_1^j t_1^j - T_1 \left|t_1^j\right| - B_1 \left(t_1^j\right)^2 + A_2^j t_2^j - T_2 \left|t_2^j\right| - B_2 \left(t_2^j\right)^2 - C t_1^j t_2^j$$

as the investor's objective, where

$$\begin{aligned} A_i^j &= \mu_i - p_i - \theta\left(\sigma_i^2 e_i^j + \sigma_{12} e_l^j\right), l \neq i \\ B_i &= \frac{1}{2}\theta\sigma_i^2, \\ C &= \theta\sigma_{12}. \end{aligned}$$

The investor chooses t^j to max $\Psi(t^j; p, T)$. Note that Ψ may be negative, but that the investor can always ensure $\Psi = 0$ by not trading ($t^j = 0$). Despite the lack of differentiability of Ψ, the solution to the portfolio problem is straightforward (see Constantinides (1979) for a similar argument). Because Ψ is strictly concave on each of the four orthants of the (t_1, t_2) - plane, the solution of the problem when restricted to an orthant is unique and given by the first-order condition, whenever it exists. An inspection of the gradient of Ψ on the axes then shows that the necessary conditions for the solution to be in a given orthant are also sufficient. Hence, the solution to the portfolio problem is unique and given by the first-order condition whenever the optimum is in the interior of one of the four orthants. The first order condition is

$$A_i^j - T_i \delta_i^j = 2B_i t_i^j + C t_l^j, i = 1, 2, l \neq i.$$

which is equivalent to

$$\begin{pmatrix} t_1^j \\ t_2^j \end{pmatrix} = \frac{1}{4B_1B_2 - C^2} \begin{pmatrix} 2B_2 \left(A_1^j - T_1\delta_1^j\right) - C\left(A_2^j - T_2\delta_2^j\right) \\ -C\left(A_1^j - T_1\delta_1^j\right) + 2B_1\left(A_2^j - T_2\delta_2^j\right) \end{pmatrix} \tag{9}$$

where $4B_1B_2 - C^2 = \theta^2 |\Sigma|$ is strictly positive. Solving (9) for t^j produces four different regimes where the investor wants to trade both assets (called R1-R3 in the lemma below), one for each orthant in the (t^1, t^2) - plane (corresponding to the four possible directions of trade). If there is no solution in the interior of the four orthants (i.e. if the parameter conditions corresponding to $t^j >> 0$ in (9) are violated), there can be a solution on the axes. In particular if transactions costs of one risky asset are sufficiently large relative to those of the other and the latter are sufficiently small, then there is a solution on the axis where only one asset is demanded (R4). Otherwise asset demand is zero. This is the contents of the following lemma.

Lemma 1 *The investor's portfolio problem has a unique solution, given as follows.*

R1 *If* $\sigma_1^2\sigma_2^2(A_1^j - T_1) > \sigma_1^2\sigma_{12}(A_2^j - T_2) > \sigma_{12}^2(A_1^j - T_1)$, *investor* j *buys both assets, and*

$$t_i^j = \frac{\sigma_l^2}{\theta\,|\Sigma|}\left(\mu_i - p_i - T_i\right) - \frac{\sigma_{12}}{\theta\,|\Sigma|}\left(\mu_l - p_l - T_l\right) - e_i^j > 0, \quad i = 1, 2, l \neq i.$$

R2 *If* $\sigma_{12}^2(A_2^j + T_2) > \sigma_2^2\sigma_{12}(A_1^j + T_1) > \sigma_1^2\sigma_2^2(A_2^j + T_2)$*, investor* j *sells both assets, and*

$$t_i^j = \frac{\sigma_l^2}{\theta|\Sigma|}(\mu_i - p_i + T_i) - \frac{\sigma_{12}}{\theta|\Sigma|}(\mu_l - p_l + T_l) - e_i^j < 0, \quad i = 1, 2, l \neq i.$$

R3 *If* $\sigma_i^2\sigma_{12}(A_l^j + T_l) < \min(\sigma_1^2\sigma_2^2(A_i^j - T_i), \sigma_{12}^2(A_i^j - T_i))$*,* $i = 1, 2, l \neq i$*, investor* j *sells asset* l *and buys asset* i*, and*

$$\begin{aligned} t_i^j &= \frac{\sigma_l^2}{\theta|\Sigma|}(\mu_i - p_i - T_i) - \frac{\sigma_{12}}{\theta|\Sigma|}(\mu_l - p_l + T_l) - e_i^j > 0 \\ t_l^j &= \frac{\sigma_i^2}{\theta|\Sigma|}(\mu_l - p_l + T_l) - \frac{\sigma_{12}}{\theta|\Sigma|}(\mu_i - p_i - T_i) - e_l^j < 0. \end{aligned}$$

R4 *If* $\left|A_i^j\right| > T_i$ *and* $T_l \geq sign(A_l^j)\left(A_l^j - \frac{\sigma_{12}}{\sigma_i^2}\left(A_i^j - sign(A_i^j)T_i\right)\right), l \neq i$*, investor* j *only trades asset* i*:*

$$t_i^j = \frac{1}{\theta\sigma_i^2}(A_i^j - sign(A_i^j)T_i) \neq 0, t_l^j = 0.$$

R5 *If none of the above conditions hold, investor* j *does not trade:* $t^j = 0$*.*

The Lemma is tedious to derive but quite standard. In particular, it shows the existence of a "no-trading region" (Constantinides, 1979): there is no trade if transactions costs are too high or initial endowments too close to the optimal allocation without transactions costs.

We now determine equilibrium in the asset markets. As can be seen from Lemma 1, there are four types of equilibria. First, there is the possibility that one investor buys both assets and the other sells both (regime R1 for investor j, regime R2 for investor $k \neq j$). Second, there is the possibility that one investor buys asset 1 and the other buys asset 2 (regime R3 for both investors j, with different indices). Third, there is the possibility that investors trade only one asset (R4). And fourth, there is the no-trade equilibrium. It is useful to label the four full-trading equilibria by their directions of trade: (δ_1, δ_2), where δ_i is $+1$ if investor type 1 buys asset i and is -1 if he sells.

Given the simple structure of our model, it is possible to calculate the equilibrium explicitly. This is relatively time-consuming, so we relegate the calculation to the appendix. The result is in the following proposition.

Proposition 2 *The different types of equilibria exist under the following conditions:*

- *A full-trading equilibrium of type* (δ_1, δ_2) *exists if and only if*

$$\sigma_2^2 T_1 - \delta_1 \delta_2 \sigma_{12} T_2 + \delta_1 \frac{\theta}{2} |\Sigma| \Delta_1 < 0 \quad (10)$$

$$\sigma_1^2 T_2 - \delta_1 \delta_2 \sigma_{12} T_1 + \delta_2 \frac{\theta}{2} |\Sigma| \Delta_2 < 0 \quad (11)$$

  Equilibrium prices and trades in asset $i = 1, 2$ $(l \neq i)$ *are*

$$p_i^* = \mu_i - \theta \left(\sigma_i^2 s_i + \sigma_{12} s_l \right) - \delta_i T_i \left(\omega^1 - \omega^2 \right), \quad (12)$$

$$t_i^1 = -\omega^2 \Delta_i - \frac{2\omega^2}{\theta |\Sigma|} \left(\delta_i \sigma_l^2 T_i - \delta_l \sigma_{12} T_l \right). \quad (13)$$

- *For* $i = 1, 2$*, an equilibrium with* $t_i^1 \neq 0$ *and* $t_l^1 = 0$*,* $l \neq i$*, exists if and only if*

$$T_l \geq \frac{1}{\sigma_i^2} \left| \frac{1}{2} \Delta_l |\Sigma| \theta - \sigma_{12} T_i \right| \quad (14)$$

$$\text{and } T_i < \frac{\theta}{2} \left| \Delta_i \sigma_i^2 + \Delta_l \sigma_{12} \right|. \quad (15)$$

  The equilibrium price and trade in asset i is

$$p_i^* = \mu_i - \theta \left(\sigma_i^2 s_i + \sigma_{12} s_l \right) - \delta_i T_i \left(\omega^1 - \omega^2 \right), \quad (16)$$

$$t_i^1 = -\frac{\omega^2}{\theta \sigma_i^2} \left[\theta (\Delta_i \sigma_i^2 + \Delta_l \sigma_{12}) + 2 \delta_i T_i \right]. \quad (17)$$

- *If none of the previous conditions hold, there is no trade.*

The proposition shows that aggregate endowments or relative investor size (ω^j) play no role for the existence of equilibrium. The key parameter entering the existence conditions is the difference in per capita endowments between investor 1 and 2, $\Delta_i = e_i^1 - e_i^2$. For example, an equilibrium in which investor 1 buys both assets (the case $\delta_1 = \delta_2 = 1$) exists if Δ_1 is sufficiently small compared to T_1 and $|\Delta_2|$ sufficiently large compared to T_2 (conditions (10) and (11)).

On the other hand, the size of the groups of investors plays a role for prices. (12) shows that equilibrium prices, as expected, depend positively on the expected cash flow and negatively on the supply of both assets. Yet, the impact of transaction costs can be positive or negative depending on the weights of the group of investors. For instance, if $\omega^1 > \omega^2$ and investor 1 buys asset i in equilibrium, then the price of asset i decreases with T_i; if investor 1 sells, the price increases with T_i.

The interesting part of Proposition 2 is the interaction between transactions costs and endowment differentials in the determination of trading volume (the first being the impediment, the latter the motive for trade). As to be expected, the trading volume of each risky asset goes down if its transactions costs increase. But for the trading decision of any one asset also the trading costs of the other asset are relevant because of correlation (the hedging motive). Their effect depends on whether the investors in equilibrium trade in the same direction for both assets or not.[11] If one investor class buys/sells both assets in equilibrium, trade in one asset increases the higher are the transaction costs of the other asset (the assets behave like substitutes), and the strength of the effect increases with σ_{12}. Inversely, if each investor class buys one asset and sells the other ($\delta_1\delta_2 = -1$), investors trade less of an asset the higher are the transaction costs of the other asset (the assets behave like complements). Whether $\delta_1\delta_2$ is positive or negative is, of course, endogenous, and we characterize its sign in the next sub-section.

The equilibrium price when only one asset is traded has the same structure as that for full trading. However, equilibrium trades are different because the hedging motive is missing compared to the full-trading equilibria. The conditions (14) and (15) show that a simultaneous combination of high transaction costs for asset l, small degree of home bias and small transaction costs for asset i can lead to an equilibrium where only asset i is traded.

3.3 Equilibrium trade

It is useful to note how the relative size of endowments restricts the possible directions of equilibrium trades. In the "bi-directional" equilibria $\delta_1\delta_2 = -1$ (each investor class buys one risky asset), the decision of investor 1 to trade

[11] If in equilibrium $t_1^1 > 0, t_2^1 > 0$, an increase in T_1 decreases t_1^1 and increases t_2^1. If $t_1^1 > 0, t_2^1 < 0$, an increase in T_1 decreases t_1^1 and decreases $|t_2^1|$.

is given by the following inequalities:

$$t_i^1 > 0 \Leftrightarrow \sigma_l^2 T_i + \sigma_{12} T_l < -\frac{\Delta_i \theta \left|\Sigma\right|}{2} \quad (18)$$
$$t_i^1 < 0 \Leftrightarrow \sigma_l^2 T_i + \sigma_{12} T_l < \frac{\Delta_i \theta \left|\Sigma\right|}{2} \quad (19)$$

In particular, the trading decision depends on the relative endowment Δ_i as follows.

- If $\Delta_i > 0$ (investor 1 owns more of asset i than 2) then $t_i^1 > 0$ is impossible. Hence, the large owner does not buy. The only possible outcome is investor 1 selling asset i (if Δ_i is sufficiently large and both transactions costs sufficiently small).
- If $\Delta_i < 0$ (investor 1 owns less of asset i than 2) investor 1 buys asset i if $\sigma_l^2 T_i + \sigma_{12} T_l < -\Delta_i \theta \left|\Sigma\right| /2$ and never sells.

Hence, in the "bi-directional" equilibria, the large owner always sells and the small one always buys. These are the same directions of trade as in the case of no transactions costs (see (8)).

In the "unidirectional" equilibria $\delta_1 \delta_2 = 1$ (one investor class buys both assets) investor 1's decision to trade depends on the following inequalities:

$$t_i^1 > 0 \Leftrightarrow \sigma_l^2 T_i - \sigma_{12} T_l < -\frac{\Delta_i \theta \left|\Sigma\right|}{2} \quad (20)$$
$$t_i^1 < 0 \Leftrightarrow \sigma_l^2 T_i - \sigma_{12} T_l < \frac{\Delta_i \theta \left|\Sigma\right|}{2} \quad (21)$$

Now, the impact of endowments on trading decisions is richer. Suppose for example $\Delta_i > 0$. Then both decisions, $t_i^1 > 0$ and $t_i^1 < 0$, can occur. In particular, if $\sigma_l^2 T_i - \sigma_{12} T_l < -\Delta_i \theta \left|\Sigma\right| /2$, then the equilibrium will have investor 1 buy asset i, although he already owns the larger amount of the asset. Necessary for this outcome is $\sigma_l^2 T_i < \sigma_{12} T_l$, i.e., a relatively strong correlation between the assets and relatively high transactions costs for the other asset.

A similar conclusion obtains for the case $\Delta_i < 0$. Hence, in the "unidirectional" equilibria it is possible that the relatively larger (smaller) investors buy (sell) the asset, thus reinforcing the home bias. This can happen if the correlation between assets is sufficiently high and the foreign asset is expensive to trade. In this case, domestic investors can prefer to re-balance their portfolio by taking on even more of the domestic asset. This is the opposite direction of trade to the case of no transactions costs.

The above discussion has shown that the distribution of initial endowments as reflected in the Δ_i influences what type of equilibrium can prevail. In fact, some equilibrium configurations can be ruled out as a function of the Δ_i, for others the Δ_i imply restrictions on the transactions costs T_i. We now study this issue more generally by asking what equilibria exist for which values of $T = (T_1, T_2)$. For this discussion, it is useful to introduce the parameters

$$\overline{T}_i = \frac{\theta}{2} \left| \Delta_i \sigma_i^2 + \Delta_l \sigma_{12} \right|, l \neq i. \tag{22}$$

Below we will see that Proposition 2 implies that an equilibrium in which asset i is traded exists only if $T_i < \overline{T}_i$.

Our basic assumption that $\Delta_1 > 0$ and $\Delta_2 < 0$ (investor 1 owns more of asset 1, investor 2 more of asset 2), immediately implies, after an inspection of (10) and (11), that $\delta_1 = 1$ and $\delta_2 = -1$ (investor 1 buys asset 1 and sells asset 2) is impossible in equilibrium. Furthermore, it is clear that an equilibrium in which investor 1 sells asset 1 and buys asset 2 will exist if transactions costs are not too high (this is the "natural" direction of trade that would erode the home bias and occur without transactions costs).

Yet, the "uni-directional" equilibria $\delta_1 \delta_2 = 1$ are also possible. Investor 1 will buy both assets if and only if the two conditions in (10) and (11) for $\delta_1 = \delta_2 = 1$ are compatible for some values of T, which is the case iff the two straight lines defined by this condition intersect in the positive orthant of $T_1 - T_2$ - space. This is true iff $\sigma_1^2 \Delta_1 + \sigma_{12} \Delta_2 < 0$. Similarly, one can see that investor 2 will buy both assets for some values of T if and only if $\sigma_{12} \Delta_1 + \sigma_2^2 \Delta_2 > 0$. In the remaining case, $\Delta_1 \sigma_1^2 / \sigma_{12} > -\Delta_2 > \Delta_1 \sigma_{12} / \sigma_2^2$, only the "natural" equilibrium $\delta_1 = -1, \delta_2 = 1$ is compatible with $\Delta_1 > 0, \Delta_2 < 0$.

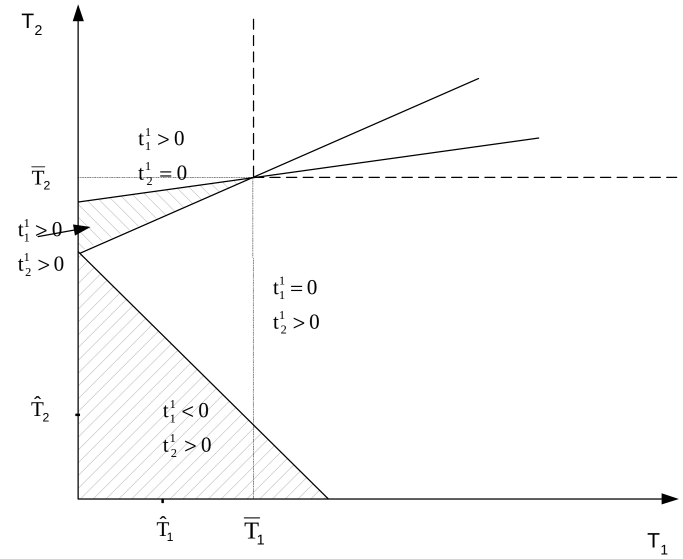

Figure 1: The trading region if $0 < \Delta_1\sigma_1^2/\sigma_{12} < -\Delta_2$

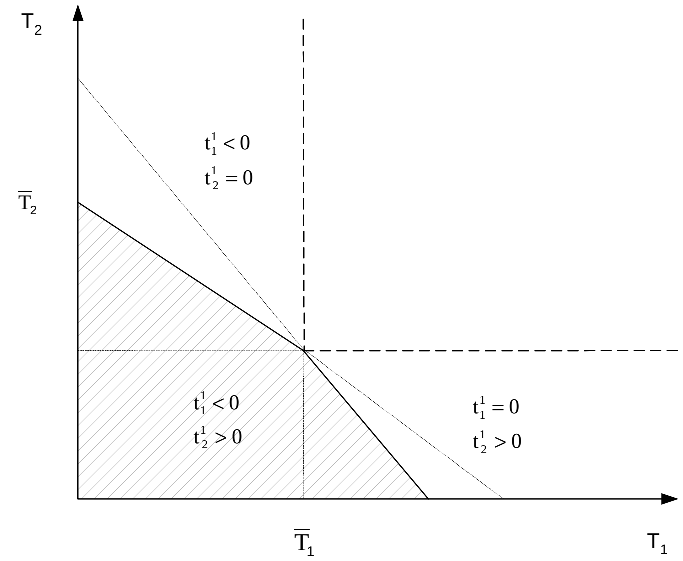

Figure 2: The trading region if $\Delta_1\sigma_1^2/\sigma_{12} > -\Delta_2 > \Delta_1\sigma_{12}/\sigma_2^2 > 0$

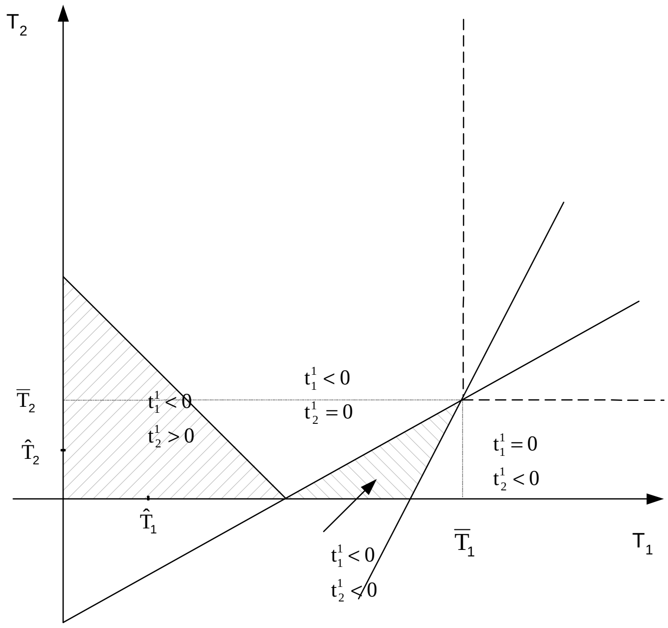

Figure 3: The trading region if $0 < -\Delta_2 < \Delta_1\sigma_{12}/\sigma_2^2$

Figures 1 - 3 present the result of the above analysis graphically. If transactions costs are not too unequal and sufficiently small (the hatched surface that contains the origin in the three figures), then, as in the case with no transactions costs, investor 1 will sell asset 1 in equilibrium and investor 2 sell asset 2. If T_1 is relatively small and T_2 relatively large, this behavior is impossible, and Figure 1 shows that investor 1 may rather buy both assets (the upper triangle). Yet, this happens only if Δ_1 is sufficiently small compared to $|\Delta_2|$, i.e., if investor 1 does not own much more of asset 1 than investor 2 (in other words, if the home bias for asset 1 is not too strong).

Conversely, if T_1 is relatively large and T_2 relatively small, investor 2 may buy both assets (the right-hand triangle in Figure 3). For this, it is necessary that Δ_1 and T_1 be large and $|\Delta_2|$ and T_2 small. Now the direction of trade for asset 2 is different from the case without transactions costs. The trading areas of such "distorted" decisions are marked by relatively big discrepancies between transaction costs and strongly differing endowments in one asset and by relatively small differences in endowments in the other asset.

Although we shall not pursue this in the remainder of the paper, this feature of equilibrium trading under transactions costs has some interest of its own; we therefore summarize it in the following proposition.

Proposition 3 *If $\sigma_i^2 |\Delta_i| < \sigma_{12} |\Delta_l|$, $l \neq i$, and T_i is sufficiently small compared to T_l, then investor type i buys both assets, even the domestic asset to which he is already strongly exposed.*

An interesting feature of Figures 1 and 3 is the non-convexity of the full-trading region in T - space. As an example, take the case $\sigma_1^2\Delta_1 + \sigma_{12}\Delta_2 < 0$ shown in Figure 1. Fix a sufficiently small value of T_1 (such as $\widehat{T_1}$) and vary T_2. For small T_2, the equilibrium directions of trade are as in the case without transactions costs. If T_2 increases beyond $\frac{\theta|\Sigma|\Delta_1}{2\sigma_{12}} - \frac{\sigma_2^2}{\sigma_{12}}T_1$ but is below $\frac{\theta|\Sigma|\Delta_1}{2\sigma_{12}} + \frac{\sigma_2^2}{\sigma_{12}}T_1$, only asset 2 is traded. If T_2 increases beyond $\frac{\theta|\Sigma|\Delta_1}{2\sigma_{12}} + \frac{\sigma_2^2}{\sigma_{12}}T_1$ but is below $-\frac{\theta|\Sigma|\Delta_2}{2\sigma_1^2} + \frac{\sigma_{12}}{\sigma_1^2}T_1$, there is again a full-trading equilibrium, this time one where investor 1 buys both assets. Finally, if T_2 is above $-\frac{\theta|\Sigma|\Delta_2}{2\sigma_1^2} + \frac{\sigma_{12}}{\sigma_1^2}T_1$, only asset 1 is traded. The non-convexities reflect the "distortion" of trading motives (compared to the first-best) described above.

The relative size of endowments also determines the single-asset-trading equilibria. An inspection of the conditions in Proposition 2 then yields the following result.

Proposition 4 *The asset market equilibrium is unique.*

Proof. The above discussion has shown that the four types of full-trading equilibria are mutually exclusive. Furthermore, it is straightforward to see that the conditions for single-trading equilibria imply different parameter values from the full-trading conditions. Figures 1 - 3 provide the graphical illustration. ■

4 Competition between Exchanges

We now use the results of the last section to analyze the interaction between the stock exchanges in the determination of transactions costs. This will, in particular, allow us to explore the impact of stock market integration on the equilibrium transaction costs of stock exchanges, where stock market integration is captured by the correlation of asset returns.

A problem for the analysis are the non-convexities of the "full-trading region" in T - space (see Figures 1 and 3).[12] In fact, as the analysis of Section 3 has shown, the set $\mathcal{T} = \{(T_1, T_2) \in \mathbb{R}^2_+$; there is full trade in equilibrium$\}$ is only convex for $\Delta_1\sigma_1^2/\sigma_{12} > -\Delta_2 > \Delta_1\sigma_{12}/\sigma_2^2$. If this condition does not hold, the strategy set of each exchange is non-convex, and the determination of equilibrium is more complicated. To simplify, we only consider the convex case here. As seen above, this requires that the home bias be not too strong in both countries.

Assuming that $\Delta_1\sigma_1^2/\sigma_{12} > -\Delta_2 > \Delta_1\sigma_{12}/\sigma_2^2$, only equilibria of the type $\delta_1 = -\delta_2 = -1$ are possible and total trading volume, given in Proposition 2, is

$$v_i(T_i, T_l) = \omega^1\omega^2\left[|\Delta_i| - \frac{2}{\theta|\Sigma|}\left(\sigma_l^2 T_i + \sigma_{12}T_l\right)\right], l \neq i \tag{23}$$

By Proposition 2, the full-trading region $\mathcal{T}$ is the set of all $(T_1, T_2) \in \mathbb{R}^2_+$ that satisfy conditions (10)-(11):

$$\begin{aligned} \sigma_1^2 T_2 &< -\frac{\theta|\Sigma|\Delta_2}{2} - \sigma_{12}T_1 & (24)\\ \text{and } T_2\sigma_{12} &< \frac{\theta|\Sigma|\Delta_1}{2} - \sigma_2^2 T_1 & (25)\end{aligned}$$

On the boundary of the full-trading region we have $v_i = 0$ and $v_j > 0$, if exactly one of the inequalities in (24)-(25) binds. The boundary separates the full-trading region from the two single-asset-trading regions. By Proposition 2, the region where asset i is traded alone is given by

$$\begin{aligned} T_l &\geq \frac{1}{\sigma_i^2}\left|\frac{1}{2}\theta\Delta_l|\Sigma| - \sigma_{12}T_i\right| & (26a)\\ \text{and } T_i &< \overline{T}_i, l \neq i & (26b)\end{aligned}$$

where $(\overline{T}_1, \overline{T}_2)$ is the intersection of the lines in (24)-(25) and given by (22).

Call the single-asset trading regions $\mathcal{S}_i = \{(T_1, T_2) \in \mathbb{R}^2_+$; in equilibrium there is trade only in asset $i\}$. By Proposition 2, trading volume in asset i if the other asset is not traded is

$$v_i(T_i, T_l) = \frac{\omega^1\omega^2}{\sigma_i^2}\left(\sigma_i^2|\Delta_i| - \sigma_{12}|\Delta_l| - 2\frac{T_i}{\theta}\right), l \neq i, \forall i. \tag{27}$$

[12] In the transactions literature following Constantinides and Magill (1976) and Constantinides (1979), the terms "trading region" or "no-trading region" usually refer to endowment space. For our purposes we must cast the analysis in transactions costs space.

Each exchange maximizes profits given the behavior of the other exchange by setting its fees f_i. Exchange i's formal problem is

$$\begin{aligned} \max_{f_i \geq 0} \quad & v_i(d_i + f_i, T_l)(f_i - c_i) \\ \text{where } v_i \text{ is given by (23) if } (T_1, T_2) &\in \mathcal{T}, \\ \text{by (27) if } (T_1, T_2) &\in \mathcal{S}_i, \\ \text{and } v_i &= 0 \text{ otherwise} \end{aligned}$$

When choosing its level of fees, each exchange must solve the standard oligopoly trade-off: increasing the fee increases the revenue per transaction, but decreases the total volume of transactions. In the model, two elements are outside the exchanges' control: their cost structure (given by the marginal cost level c_i) and the exogenous component of trading costs (given by d_i). It is clear that if this total cost level,

$$k_i = c_i + d_i$$

is too high, there cannot be an equilibrium with trade. However, if this level is not too high, there will be trade. The next proposition provides a precise characterization of the exchanges' optimal policies.

Proposition 5 *Assume that* $\Delta_1\sigma_1^2/\sigma_{12} > -\Delta_2 > \Delta_1\sigma_{12}/\sigma_2^2$ *and that* $k_i < \overline{T}_i$, $i = 1, 2$ *(as defined in (22)). The competition between the exchanges has a unique Nash equilibrium in which exchange* i, $i = 1, 2$, *sets*

$$\begin{aligned} f_i^* &= \frac{1}{4\sigma_1^2\sigma_2^2 - \sigma_{12}^2}\left[\theta\left|\Sigma\right|\left(\sigma_i^2\left|\Delta_i\right| - \frac{1}{2}\sigma_{12}\left|\Delta_l\right|\right) - \sigma_{12}\sigma_i^2(c_l + d_l)\right. \qquad (28) \\ &\left. -(2\sigma_1^2\sigma_2^2 - \sigma_{12}^2)d_i + 2\sigma_1^2\sigma_2^2 c_i\right], \end{aligned}$$

($l \neq i$) and makes strictly positive profits.

Proof. We first solve a simplified problem for each exchange, by assuming that v_i is given by (23) for all $T \in \mathbb{R}_+^2$ (i.e., we solve the problem as if the exchanges were always pricing in the full-trading region). To simplify notation, let $y_i = f_i - c_i$. In this problem, exchange i optimally chooses, for y_l given,

$$y_i^* = \frac{\theta\left|\Sigma\right|}{4\sigma_l^2}\left|\Delta_i\right| - \frac{\sigma_{12}}{2\sigma_l^2}(y_l + k_l) - \frac{k_i}{2}$$

Solving for (y_1, y_2) and substituting back for f_i, c_i, and d_i yields (28). We now show that $T^* = f^* + d \in \mathcal{T}$. A straightforward but lengthy calculation shows that T^* satisfies (24)-(25) if and only if

$$k_2 < -\frac{\sigma_{12}\sigma_2^2}{2\sigma_1^2\sigma_2^2 - \sigma_{12}^2}k_1 - \frac{\theta\,|\Sigma|}{2}\frac{\sigma_{12}\Delta_1 + 2\sigma_2^2\Delta_2}{2\sigma_1^2\sigma_2^2 - \sigma_{12}^2} \quad \text{(29a)}$$

$$k_2 < -\frac{2\sigma_1^2\sigma_2^2 - \sigma_{12}^2}{\sigma_{12}\sigma_1^2}k_1 - \frac{\theta\,|\Sigma|}{2}\frac{\sigma_{12}\Delta_2 + 2\sigma_1^2\Delta_1}{\sigma_{12}\sigma_1^2} \quad \text{(29b)}$$

The straight lines defined by (29a) and (29b) in $k_1 - k_2$ - space intersect in $(\overline{T}_1, \overline{T}_2)$. Therefore, the condition on k in the Proposition implies that k satisfies (29a) and (29b). Furthermore, it is straightforward to verify that also the inequalities $f_i > c_i$ are equivalent to (29a) and (29b). Hence, the f^* defined by (28) yields $T^* \in \mathcal{T}$ (i.e. leads to trade in the full-trading region) and positive profits for the exchanges.

The check whether exchanges have incentives to deviate from T^* into a single-asset-trading region is trivial, because each exchange can only price itself out of the market (see Figure 2). Thus T^* is a Nash equilibrium. It is unique, because there is no other equilibrium in the full-trading region, as shown above, and there can be no equilibrium in a single-trading region, because then the excluded stock exchange can price itself into the market and make a profit. ∎

In this equilibrium both exchanges are active and make positive profits. By inspection, equilibrium fees are determined by operational costs c_i, the difference of endowments Δ_i, exogenous costs d_i, and the variance-covariance structure of asset returns. If (differently from our assumption) operational and exogenous costs are high for one exchange and low for the other, there is typically an equilibrium in which only one exchange operates.

5 Determinants of Transactions Costs and Trading Volume

We now turn to the second objective of this paper and analyze the determinants of stock market transactions costs and trading volume. We first use the results of Section 4 to investigate how the asset structure and the trading environment influence the determination of transactions costs. This amounts to the comparative statics analysis of (28).

5.1 Stock market integration and transactions costs

Given the experience of stock markets around the world in the 1990s, we are mostly interested in the impact of market integration on transactions costs. We model market integration by the covariance or the correlation between local asset returns (σ_{12} or ρ).

For the remainder of the paper we assume that the conditions of Proposition 5 are satisfied, i.e. we assume that $\Delta_1\sigma_1^2/\sigma_{12} > -\Delta_2 > \Delta_1\sigma_{12}/\sigma_2^2$ and that $k_i < \overline{T}_i$.

Proposition 6 *Equilibrium transactions costs decrease with market integration as measured by the covariance between stock market returns σ_{12}.*

Proof. Differentiating (28) yields

$$\begin{aligned}\frac{df_i^*}{d\sigma_{12}} &= \left(\frac{1}{4\sigma_1^2\sigma_2^2-\sigma_{12}^2}\right)^2\Big(-6\theta\,|\Delta_i|\,\sigma_{12}\sigma_i^2\sigma_1^2\sigma_2^2-\frac{1}{2}\theta\,|\Sigma|\,|\Delta_l|\,(4\sigma_1^2\sigma_2^2+\sigma_{12}^2) \\ &\quad +\theta\,|\Delta_l|\,\sigma_{12}^2(4\sigma_1^2\sigma_2^2-\sigma_{12}^2)-\sigma_i^2(4\sigma_1^2\sigma_2^2+\sigma_{12}^2)k_l+4\sigma_{12}\sigma_1^2\sigma_2^2k_i\Big)\end{aligned} \tag{30}$$

This together with the two restrictions

$$k_i < \frac{\theta}{2}\left(|\Delta_i|\,\sigma_i^2-|\Delta_l|\,\sigma_{12}\right) \text{ and } |\Delta_i|\,\sigma_i^2 > |\Delta_l|\,\sigma_{12}, l \neq i. \tag{31}$$

yields the result. ■

The intuition behind Proposition 6 is simply a combination of decreased demand for diversification by investors with price competition by exchanges. In fact, an inspection of equilibrium trading volumes (23) shows that they are decreasing in the covariance of asset returns. This in turn implies that the price competition between the exchanges intensifies, leading to reduced fees.

Table IV
Average Stock Market Correlations 1973 - 2003

The table shows average correlations calculated from DataStream market indexes (our calculations). The data provided by DataStream is weekly returns calculated in US dollars, from January 1, 1973 to November 25, 2003 (1613 observations). The subsamples are 1973-1982 (522 observations), 1983-1992 (522 observations) and 1993-2003 (569 observations). Countries are Australia (Aus), Canada (Ca), France (Fr), Germany (Ger), Italy (It), Japan, (Jap), the Netherlands (NL), Switzerland (CH), United Kingdom (U.K), United States (U.S).

	U.S., U.K., Ger, Fr	U.S., U.K., Ger, Fr, Aus,Ca, It, Jap, NL, CH
1973-1982	0.32	0.33
1983-1992	0.46	0.44
1993-2003	0.71	0.57

The proposition is consistent with the observed strong trends of increasing economic integration and decreasing transaction costs in stock markets around the world in the 1980s and 90s. As Table IV shows by means of two examples, the correlation of returns on all major stock exchanges has increased steadily from the 1970s to the 2000s. There has been some debate about whether this trend is due to increased "fundamental" integration of the underlying economies or whether it rather reflects a financial phenomenon.[13] Economic integration has certainly been important in Continental Europe in the 1980s and 1990s and is often viewed as the source of intensified competition in financial markets, as well. The ultimate answer to this question is of little importance to our argument, as long as financial market integration acts as a driver for stock exchange competition.

On this front, it is widely acknowledged that stock exchange competition has increased world-wide since the 1980s. The main catalyzing event has been the so-called Big Bang, a set of reforms that liberalized the London stock market in 1986, with a major impact on commissions and spreads. Pagano and Roell (1990) report a fall of one third on large transaction costs after the Big Bang. These reforms were soon followed by other continental exchanges. In 1989, Paris liberalized members' commissions, reduced stamp duty and implemented an automated traded system. Progressively, similar reforms were adopted all over the world, leading to further drastic

[13]See Adam, Jappelli, Menichini, Padula, and Pagano (2002), Goetzmann, Li and Rouwenhorst (2001), Galati and Tsatsaronis (2001), and Bekaert and Harvey (2003), the latter for market openings in emerging markets.

declines in transactions costs since the mid-90s.[14] Consistent with the proposition, Domowitz, Glen, and Madhavan (2001) found that transaction costs in emerging markets, who are less well integrated with developed markets, are approximately the double of those in developed markets.

5.2 Other determinants of transactions costs

A second important determinant of transactions costs are operational costs of stock exchanges. It has been widely remarked that technological intermediation costs for exchanges have decreased dramatically during the 1990s. In particular, the advent of electronic trading platforms has reduced the costs of market making for stock exchanges considerably. We capture these costs in our model by the variable cost parameter c_i. Trivially, an inspection of (28) shows that reduced costs c_i are partially passed through to customers in our model in the form of lower fees f_i.[15] This is consistent with the finding of Domowitz, Glen, and Madhavan (2001), in their international comparison of stock exchange characteristics, that automated markets have lower fees. Furthermore, the impact of costs on fees is higher when stock market integration is stronger ($\partial^2 f_i/\partial c_i \partial\sigma_{12} > 0$).

What is interesting to note, however, is that a global decrease of intermediation costs does not necessarily lead to globally decreasing transactions fees. In fact, because transactions costs depend on own and foreign intermediation costs with different signs, they will decrease differentially depending on the variance-covariance structure of asset returns and may even increase for an exchange if the covariance is sufficiently high.

Next, we can note that markets with a stronger home bias have higher fees (because $\frac{\partial f_i}{\partial|\Delta_i|} > 0$). As stock market integration increases, the importance of $|\Delta_i|$ in determining fees decreases, and operational costs become the main determinant. This is one possible explanation for the finding by Domowitz, Glenn and Madhavan (2001) that transaction costs in emerging markets are approximately the double of those in developed markets.

Exogenous trading costs d_i have a negative impact on fees. The intuition is simple: As trading depends only on total transactions costs, an increase in exogenous transactions costs must at least partially be compensated by

[14] See, e.g., Domowitz, Glen, and Madhavan (2001) for an excellent survey.

[15] See Domowitz (2001) for a more detailed analysis of how cost reductions can be obtained via automated trading systems.

reduced endogenous transactions if exchanges maximize profits. As fees optimally decrease with increasing exogenous transactions costs, this does not only hurt investors but also the stock exchanges. This explains why exchanges in the last decade have assumed a more active role in organizing and imposing rules on trade. In fact, many of the reforms of stock exchanges have been fostered by exchanges themselves, and part of their efforts have been directed at reducing these "undesirable competitive" costs. There are several examples, such as the lobbying for the decrease of taxes, imposing stricter transparency standards for firms (e.g. Deutsche Börse and Stockholm's Borssen). Partnerships with financial data providers aim at decreasing information costs, mergers of clearing houses and settlement systems, as the one of Clearnet and LCH, intend to improve costs associated with cross border trading.

Last but not least, our model implies a positive relationship between transaction costs and volatility. This relationship is well-known empirically and usually interpreted as transactions costs causing volatility through reduced market liquidity. Our model suggests the reverse causality: the higher is the variance of the asset, the smaller is the absolute impact of transaction costs in the trading region. Hence, when the precision of cash flows increases, fees are pressured to decrease.

In summary, when we compare the variables of our model with the empirical determinants of transactions costs identified by Domowitz, Glen and Madhavan (2001), our model produces comparative statics in line with their empirical findings. In particular, turnover, market capitalization (a proxy of the endowments), volatility, economic development (a proxy for correlation) and market automation (a proxy for operational costs) have the impact predicted by our model.

5.3 Short and long run determinants of trading volume

In the presence of transactions costs, changes in the trading environment, such as the international variance-covariance structure of asset returns, induce changes in trading flows. However, focusing on the short-run changes alone is likely to distort the picture. As shown above, changes in the trading environment also induce changes in transactions costs, which in turn will influence market activity. If one wants to understand long-term movements of trading flows, it is therefore important to integrate such longer-run indirect effects into the analysis.

The impact of market integration is a case in point. Denoting (with a slight abuse of notation) the trading volume of asset i in (23) by $v_i(f_i, f_l)$, the short-run impact of a change in σ_{12} is

$$\frac{\partial}{\partial \sigma_{12}} v_i = -\frac{2\omega^1\omega^2}{\theta |\Sigma|^2} \left((\sigma_1^2\sigma_2^2 + \sigma_{12}^2) T_l + 2\sigma_{12}\sigma_l^2 T_i \right) < 0 \tag{32}$$

Here an increase in correlation leads to reduced trading, because diversification demand decreases. However, this is not what has been observed for example in Europe in the 1990s, where increased integration has led to increased trading. While this may be due to a number of factors outside our model, such as increased spillovers in real activity, our model also sheds light on the issue. In fact, as the following proposition shows, the reduction of transactions costs identified in Proposition 6 overcompensates the direct short-term effect in (32).[16]

Proposition 7 *In the short run, an increase in stock market integration decreases trading volume, in the long run it increases trading volume.*

Proof. The short run is given by (32). The long-run effect is

$$\frac{d}{d\sigma_{12}} v_i = \frac{\partial v_i}{\partial \sigma_{12}} + \frac{\partial v_i}{\partial f_i}\frac{\partial f_i^*}{\partial \sigma_{12}} + \frac{\partial v_i}{\partial f_l}\frac{\partial f_l^*}{\partial \sigma_{12}}$$

A lengthy calculation using (30), (32), and (31) shows that this derivative is positive. ■

Similarly, we can study the long-run impact of other parameters on trading volume. For instance, the exchanges' operational costs obviously do not influence their trading volume directly, but they are determinants of investor transaction costs, which in turn influence trading volume. Hence, a decrease in an exchange's operational cost increases its long-run trading volume.

[16] Besides the effect on σ_{12}, long-term stock market integration in our model should affect the fixed transactions costs for investing on foreign stock exchanges. Part of these costs are regulatory, language or cultural barriers (see, e.g., Kang and Stulz (1997) or Hau (2001)). Although our d_i does not distinguish between local and foreign fixed transactions costs, this can be easily incorporated into the analysis.

6 Conclusion

This paper analyzes the competition between stock exchanges in the framework of asset pricing theory. Using a standard mean-variance capital market equilibrium model with transactions costs, we endogenize transactions costs as variables strategically influenced by stock exchanges. This approach has as advantage combining insights from the asset pricing and the industrial organization literature.

We derive trading volumes in this setting and show, in particular, how in some situations a home bias in one market can be exacerbated by trading. This framework is used to investigate the impact of stock market integration and other economic fundamentals on the fee policies of stock exchanges. The main result is that stock market integration decreases transaction costs because decreasing demand for international portfolio diversification increases competition between stock exchanges for portfolio flows. This is consistent with the global trend of the last decades. Furthermore, we predict that long-term trading volumes, different from short-term volumes, increase with stock market integration.

Applied studies typically take transactions costs as exogenous and try to identify their impact on trading. In their careful empirical study, Domowitz and Steil (2002), for example, estimate that a decrease of 10 percent in trading costs yields an 8 percent increase in trading volume and a 1.5 percent decrease in the cost of capital to blue-chip listed companies. These estimates show how important the effects are that we identify in this paper, but also how important it is to understand their driving forces. The present paper contributes to this task by identifying fundamentals that drive transactions costs and trading volumes simultaneously, and by shedding light on their interaction.

A Appendix

Proof of Proposition 2

The market clearing condition for the full trading equilibria is the following:

$$s_i = \frac{\sigma_1^2\sigma_2^2}{\theta\sigma_i^2\left|\Sigma\right|}\left(\mu_i - p_i\right) - \frac{\sigma_{12}}{\theta\left|\Sigma\right|}\left(\mu_l - p_l\right) + \sum_{j=1}^{2}\omega^j\left(-\frac{\sigma_1^2\sigma_2^2}{\theta\sigma_i^2\left|\Sigma\right|}T_i\delta_i^j + \frac{\sigma_{12}}{\theta\left|\Sigma\right|}T_l\delta_l^j\right) \tag{33}$$

where the rightmost term is the component of equilibrium price that varies with the different trading decisions. Solving (33) simultaneously for both assets and using Lemma 1 for the possible buy-sell combination regimes, equilibrium price simplifies to

$$p_i^* = \mu_i - \theta\left(\sigma_i^2 s_i + \sigma_{12}s_l\right) - \delta_i T_i\left(\omega^1 - \omega^2\right), l \neq i.$$

The solution is unique given that Σ is non-singular.

For determining investor's equilibrium trade in asset i, equilibrium price (12) is used on Lemma 1, returning the following expression for trade

$$t_i^1 = -\omega^2\Delta_i - \frac{2\omega^2}{\theta\left|\Sigma\right|}\left(\delta_i\sigma_l^2T_i - \delta_l\sigma_{12}T_l\right).$$

Note that the existence of prices is only defined when trade exists, therefore analyzing the trade expression (13), full trade is only possible if and only if,

$$-2\sigma_l^2T_i + 2\sigma_{12}T_l > \theta\left|\Sigma\right|\Delta_i \vee \theta\left|\Sigma\right|\Delta_i > 2\sigma_l^2T_i - 2\sigma_{12}T_l, \text{ for } \delta_i = \delta_l$$

and

$$-2\sigma_l^2T_i - 2\sigma_{12}T_l > \theta\left|\Sigma\right|\Delta_i \vee \theta\left|\Sigma\right|\Delta_i > 2\sigma_l^2T_i + 2\sigma_{12}T_l, \text{ for } \delta_i = -\delta_l.$$

which jointly with the different combinations of trade equilibria yields conditions (10) and (11). This completes the proof of Proposition (2) related with equilibrium trade in both assets.

For the equilibrium when only one asset is traded, we identify first the no-trading conditions. Note that optimal trade is given by (9). Then the investor trades in market i if $2B_l A_i^j - C\left(A_l^j - T_l\delta_l^j\right) > 2B_l T_i$ (buy) or $2B_l T_i < C\left(A_l^j - T_l\delta_l^j\right) - 2B_l A_i^j$ (sell). Conversely, market i will shut down if

$$T_i > Max\left(-\frac{C\left(A_l^j - T_l\delta_l^j\right) - 2B_l A_i^j}{2B_l}, \frac{C\left(A_l^j - T_l\delta_l^j\right) - 2B_l A_i^j}{2B_l}\right). \tag{34}$$

The expression show us that no matter the value of the equilibrium prices, T_i is too high relatively to T_l and the investor does not want to trade asset i.

Therefore, investor A buys asset i and does not trade asset l if and only if

$$T_l > -\frac{\Delta_l |\Sigma| \theta}{2\sigma_i^2} + \frac{\sigma_{12}}{\sigma_i^2} T_i \text{ and } T_l > \frac{\Delta_l |\Sigma| \theta}{2\sigma_i^2} - \frac{\sigma_{12}}{\sigma_i^2} T_i \tag{35}$$

Investor A sells asset l and does not trade asset i if and only if

$$T_l > -\frac{\Delta_l |\Sigma| \theta}{2\sigma_i^2} - \frac{\sigma_{12}}{\sigma_i^2} T_i \text{ and } T_l > \frac{\Delta_l |\Sigma| \theta}{2\sigma_i^2} + \frac{\sigma_{12}}{\sigma_i^2} T_i \tag{36}$$

which simplified yields (14).

We turn now to the condition for investor trade asset i. Solving the market clearing expression we obtain the equilibrium price

$$p_i^* = -s_i\theta\sigma_i^2 + \mu_i - \theta\sigma_{12}s_l - T_i\delta_i\left(\omega_i^1 - \omega_i^2\right)$$

Note that there is no difference with of the price on the full trading equilibrium (12). Replacing in investor 1 trade (see Lemma 1, R4) we obtain

$$t_i^{1*} = -\omega_i^2\Delta_i - \omega_i^2\frac{\sigma_{12}}{\sigma_i^2}\Delta_l - 2\omega_i^2\frac{\delta_i T_i}{\theta\sigma_i^2}.$$

therefore trade for asset i exists if and only if

$$-\frac{\theta}{2}\left(\sigma_i^2\Delta_i + \theta\sigma_i^2\sigma_{12}\Delta_l\right) > T_i \text{ or } \frac{\theta}{2}\left(\sigma_i^2\Delta_i + \theta\sigma_i^2\sigma_{12}\Delta_l\right) > T_i$$

which yields (15), completing the proof of Proposition (2).

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