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Are there Economies of Scale in Stock Exchange Activities?

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Are there Economies of Scale in Stock Exchange Activities?

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Abstract

This is the first paper that examines economies of scale in stock exchanges. The data employed in the study include cost and output statistics for 37 stock exchanges in four continents around the world for the year 1997. I estimate two traditional cost functions and find that ray (overall) scale economies exist only in the very large stock exchanges but that there are significant scale economies with respect to one of the outputs, ie the processing of trades. On the other hand, there are not equally clear scale advantages related to activities involving company-specific information. There are thus opposing forces, some tending to increase standardization and scale and others favouring the continuization of more localized facilities. The outcome of increasing competition may not be the amalgamation of exchanges but instead the centralization of certain functions, eg the trading function, and continued realization of others on a decentralized basis. There is nonetheless an obvious incentive for closer and deeper cooperation between European stock exchanges.

Keywords: stock exchanges, alliances, economies of scale, technology

JEL classification: D4, G20, G28, F33, L22, O33

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Onko arvopaperipörssitoiminnassa skaalaetuja?

Suomen Pankin keskustelualoitteita 4/99

Markku Malkamäki
Tutkimusosasto

Tiivistelmä

Tutkimus analysoi onko arvopaperipörssien toiminnassa skaalatuottoja. Analyysin kohteena on 37 eri puolilla maailmaa sijaitsevan pörssin kustanuksia ja toimintaa koskevat tiedot vuodelta 1997. Skaalaetujen olemassa oloa analysoidaan empiirisesti testaamalla perinteisiä kustannusfunktioita. Ainoastaan suurten pörssien toiminnassa löydettiin selkeät koko operatiiviseen toimintaan liittyvät skaalaedut. Pörssikauppojen prosessointiin liittyvien järjestelmien osalta skaalaedut kuitenkin ovat selkeät sekä pienissä että suurissa pörsseissä. Yrityskohtaisen tiedon käsittelyyn liittyvissä toiminnoissa sen sijaan ei havaittu yhtä selkeästi vastaavia tehokkuushyötyjä. Pörsseissä näyttääkin olevan sekä toimintoja, jotka kannattaisi yhdistää pörssien välillä että toimintoja, jotka soveltuvat parhaiten kansallisesti hoidettavaksi. Pörssitoiminnan kehitys saattaa tutkimustulosten perusteella johtaa laajoihin, useiden pörssien yhteisiin kaupankäyntijärjestelmiin. Alueelliset pörssit voivat kuitenkin perustellusti säilyä, koska niillä on parhaat edellytykset hoitaa kontakteja oman alueensa yrityksiin. Pörssien kaupankäyntijärjestelmiin liittyvän selkeän skaalaedun vuoksi Euroopan pörssitoiminnassa on odotettavissa merkittäviä rakennemuutoksia lähivuosina.

Asiasanat: arvopaperipörssit, yhteenliittymät, skaalaedut, tekniikka

JEL-luokitusnumerot: D4, G20, G28, F33, L22, O33

Contents

1 Introduction

A stock exchange is an example of a type of firm that has been a local monopoly in most countries. However, location will no longer prevent stock exchanges from competing with each other, as intermediaries and investors seek efficient cross-border services. Barriers between European securities markets have been largely removed or overcome with the implementation of the OECD codes on free movement of capital by the end of 1980s and the Investment Services Directive by the mid-1990s. The technology is already sufficiently advanced and cheap to enable investors to trade via networks. This is evidenced on a global scale in the currency and bond markets. The recent success of EUREX is a good European example of how networks are able to replace a trading floor in another country. Within this context, the introduction of the euro can only speed up the development toward a single European market for financial services. This development also implies that location will gradually lose some of its importance for market places and that competition between financial centres, market places and securities firms will intensify.

Financial institutions have already reacted to the diminishing regulatory barriers in Europe and the US and to the development of advanced telecommunication technology. There have been many mergers in Europe and the US between banks that are attempting to increase the scale of their operations. There have also been some mergers between banks and insurance companies, which suggests that these institutions see diversification of the scope of their business as advantageous. This raisesthe question of whether a similar development will take place in respect of stock market places.

Economic analysis suggests that a single market in securities will come into being if there are no regulatory barriers that prevent the formation of a single market and advanced telecommunication technologies exist, ie if the market is not dependent on physical location. This may imply a single stock exchange for securities trading if there are significant economies of scale involved in the functions of stock exchanges. By contrast, the handling of complex information may require face-to-face contacts and hence motivate the existence of multiple market places for securities. This paper aims to contribute to the discussion on the future of stock exchanges by providing an empirical analysis on economies of scale in 37 stock exchanges around the world.

It is somewhat confusing thatthe empirical results in the academic literature are so mixed as regards the existence of economies of scale and scope and the effects of telecommunication technology, this being a very challenging area of policymaking . Banks' performance, for example, has been a focus of substantial theoretical and empirical research for a long time (see eg Berger and Humphrey 1997 and Berger and Mester 1997). These studies find that inefficiencies exist in banking, but there is no consensus on the sources of the differences in measured efficiency. Economies of scale are not generally found in banking studies.

There are also some studies that have focused on scale economies in information processing and the future of financial centres. Davis (1990) discusses the future of financial centres in the light of optimal location theory of the firm and oligopoly theory. He concludes that the harmonization of regulation in the EU countries and the development of technology should lower entry barriers and tighten competition between local financial centres and hence lead to decline in natural monopolies. Thus economies of scale in financial services may lead to the emergence of a single global centre in Europe, with smaller centres in each country.

Gaspar and Glaeser (1996) model cities as a means of reducing the fixed cost involved in face-to-face interactions. They argue that straightforward information can easily be transferred through electronic networks. However, with complex information, instructions may easily be misunderstood, so that face-to-face communication is required. Their empirical work shows that telecommunications may in fact be a complement, or at least not a strong supplement for financial centres. Their analysis does directly contradict a commonly made argument that telecommunications will eliminate the significance of location.[1]

Gehrig (1998b) models competition between market places. According to his two-dimensional spatial model, there are strong forces for agglomeration, but multiple markets will exist under free entry of firms when markets are large enough. Another interesting outcome of the model is that deregulation of transaction taxes is an equilibrium reaction to a significant decline in transportation costs.

Gehrig (1998a) provides us with a recent survey of the literature on the geography of financial activity. He argues that geographical dispersion of financial activity exists because financial markets are not frictionless, in contrast to the usual assumption in finance literature. He divides factors underlying the development of financial centres into centripetal and centrifugal groups, as was suggested already by Kindleberger (1974). Economies of scale are the major centripetal force, according to Kindleberger and Gehrig. They argue that such economies are found in payment and settlement systems as well as in currency trading systems.[2] Other centripetal forces, according to Gehrig (1998a), are informational spillovers, market liquidity and thick market externalities, such as a liquid labour market. The centrifugal forces arise from market access costs and localization of information. Market access costs include transportation costs, as in Gehrig (1998b), and transaction costs that do not depend on distance. The latter were analysed in Pagano (1989).

Gehrig (1998a) argues further that centrifugal forces should be particularly relevant in the markets for instruments that are priced on the bases of complex local information, ie stocks and derivatives. Trading in these kinds of instruments is also likely to be concentrated in local financial centres instead of global financial centres or electronic trading systems.

Malkamäki and Topi (1999) survey the literature on the euro and its effects on short-term money, securities and derivatives markets. They also discuss consequences of the changes in the market structures for financial institutions, ie stock and derivatives exchanges and securities settlement systems. Interestingly, they find that liquidity in respect of bond derivatives has already shifted from national derivatives exchanges to the Eurex, which is the centre of trading in German bund derivatives. This development is consistent with Gehrig (1998a), as parallel concentration has not taken place in the trading of stock derivatives.

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[1] For a discussion of this issue, see Gaspar and Glaesser (1996), Gehrig (1998a) and O'Brien (1992).

[2] Bauer and Hancock (1995) actually found that there are significant scale economies in providing payment services in the Federal Reserve automated clearing house.

The success of Eurex relative to LIFFE may, on the other hand, be partly explained by differences in the governance of these two exchanges. Hart and Moore (1996) argue that in cooperative exchanges members may be reluctant to accept changes that would affect their own business, even if this is not in their own interest in the longer run. According to this argument, LIFFE paid a high price for developing its electronic trading system as late as it did.

It was found in this study that a stock exchange performs two functions, which produce two kinds of output. Stock exchanges have computers, software, and personnel for matching and processing trades. The trading function involves the execution of limit and market orders, which comprise highly standardized information. The empirical analysis showed that this function entails economies of scale and could therefore be based on technology that is standardized throughout each country or even throughout Europe as a whole, as has in fact happened in the US. However, centralization of technology raises the question of the sharing of income between exchanges – an issue that needs to be resolved to facilitate the formation of alliances.

The second function performed by a stock exchange involves the personnel and regulation needed to maintain the marketplace and to communicate with companies in order to handle the listing of companies and to monitor how company-specific information is released. Because this information is complex, its handling may well require face-to-face contacts. Significantly, the results of this study indicate that this function entails little or no returns to scale. Thus it might be optimal that listing procedures and communication with companies and other related matters continue to be handled at the national-exchange level in Europe.

The remainder of the paper is organized as follows. Section 2 discusses operations and performance of stock exchanges around the world. Section 3 describes the cost functions to be estimated. The next section describes the data and provides some comparisons between the stock exchanges. Empirical results on cost functions are presented in section 5 and finally the key findings and policy recommendations are presented in section 6.

2 Operations and performance of the stock exchanges

In most European and Asian countries, stock exchanges have historically been local monopolies. This is in sharp contrast with the North American exchanges, which compete with each other throughout the US and Canada. Due to this competition, the number of exchanges has declined over the years in the US. The latest mergers of AMEX and the Philadelphia Stock Exchange with NASDAQ were announced last year.

With the emergence of the euro, competition between the European stock exchanges will intensify. Globalization of industrial and financial companies increases the need for intercontinental gross-listings, which will increase competition between stock exchanges across continents. It is therefore instructive to compare the activities and relative performance of the European stock exchanges in 1996. From table 1, one can see that European exchanges handled about 50 % less transactions and other output than the North American exchanges, generated almost as much cost as the North American exchanges and generated as much profit as the stock exchanges in the rest of the world. It is also important to note that average cost per transaction at the end of 1996 was about three times higher in Europe that in the North America, FIBV (1997).

Table 1. **Exchange statistics by region in 1996, % of total**

1996 %	Capitalization	Transactions	Value of share trading	Revenues	Costs	Profits
Asia	26	39	16	29	28	32
Europe	26	20	32	36	32	49
North America	46	40	51	29	35	7
South America	2	1	1	6	5	12
	100	100	100	100	100	100

Source: FIBV 1997, Annual Report

This could mean that European stock exchanges have taken advantage of their monopolistic position in the pricing of services. Hence one might well conjecture that this monopolistic market position might have led to cost inefficiencies. In that case, quick measures would be needed to cut costs and improve the quality of services in order to create more liquidity for share trading, if the European stock market is to remain globally competitive. It is clear that international securities houses will want to keep their own costs down and their efficiency up. They will not want to pay membership fees to many European stock exchanges and to have dozens of different terminals for trading and settlement of trades. Instead, they are looking forward to having liquid European instruments and an efficient trading infrastructure. If these are not available in Europe, the securities houses will be able to trade in the shares of the biggest European listed companies on the NYSE and NASDAQ. This is the case because customer demand for cross-border transactions has already increased, as portfolios become increasingly diversified on a global scale. The value of cross-border transactions will increase manifold with the advent of the euro.

European stock exchanges are however rearranging their operations in order to be more competitive. They are attempting to gain scale advantages by forming bilateral or multilateral alliances among themselves. Such alliances exist already between 1) nine exchanges in Germany, 2) four exchanges in Spain, three exchanges in the Benelux countries, 4) three exchanges in the Scandinavian countries, and 5) the Vienna Stock Exchange and Deutsche Börse. Furthermore, the London Stock Exchange and the Helsinki Exchanges have separately signed a letter of intent to form an alliance with Deutsche Börse. At the same time, many European stock exchanges have diversified their business into derivatives and securities settlementas a way of achieving economics of scope.

However, there has not been much concrete progress so far, even though we have seen many announcements of alliances or letters of intent to establish alliances. At the same time, we know that the number of stock exchanges has been declining continuously in the US since the 1930s. Furthermore, in the US, stock exchanges generally merge instead of forming an alliance, in order to be able to compete with the NYSE. These observations, together with the example of rapid expansion of Eurex relative to LIFFE, may indicate that cost efficiency as well as the importance of efficient microstructure of trading systems has been underestimated in Europe. It is therefore crucial for the listed companies and the investment community that European alliances not turn out to be manoeuvres aimed at protecting current institutions rather than purposeful expansions aimed at cutting costs and increasing competitiveness.

It is however likely that cooperation among European stock exchanges will continue to be based on alliances. This may also be rational because of the fact that Europe is more heterogeneous with respect to language, culture and bankruptcy legislation, for example. It seems highly useful to analyse the situation to determine which operations of local stock exchanges are subject to returns to scale and are thus more likely to be included in the cooperative activities of European stock exchanges.

A close look at the operations and annual reports of the stock exchanges indicates clearly that stock exchanges perform two functions and produce two outputs. Stock exchanges have computers, software and personnel for matching and processing trades. They also have the personnel and regulations needed to maintain the marketplace and to communicate with companies in order to handle the listing of companies and to monitor how company-specific information is released and whether companies observe the regulations set by the marketplace.

The economic literature suggests that activities that are based on very simple information are likely to be centralized. My hypothesis is that limit orders and market orders can be considered standardized information, and the processing of this information is technical and not issuer-specific, ie all the transactions are treated in more or less the same way in the trading system. Thus execution of trades could be based on technology that is standardized throughout each country or even throughout Europe.

The literature also suggests that complex information, by contrast, may require face-to-face contacts for proper understanding. Centralization in this area may cause congestion problems and may also introduce a ‘transportation cost’ that is very high. It might therefore be optimal that listing procedures and communication with companies and other related matters be handled by the national exchanges also in the future. All this amounts to the empirical question of the existence of scale economies in stock exchange operations. Scale economies of the two functions, trade processing and firm-specific contacts, will be subject to an empirical analysis in the rest of the paper.

3 The model

Specification

As a starting point for the analysis, I estimate the commonly used translog cost function (see eg Berndt 1991). The translog function has the nice feature that it allows scale economies to vary with the level of output. The translog cost function with two outputs can be written:

$$\ln C = \ln\alpha_0 + \alpha_1 \ln Y_1 + \alpha_2 \ln Y_2 + \tfrac{1}{2}\gamma_{11}(\ln Y_1)^2 + \tfrac{1}{2}\gamma_{22}(\ln Y_2)^2$$
$$+ \sum_i \beta_i \ln P_i + \tfrac{1}{2}\sum_i \sum_j \gamma_{ij} \ln P_i \ln P_j + \gamma_{12} \ln Y_1 \ln Y_2 \quad (1)$$
$$+ \sum_i \sum_j \gamma_{ij} \ln P_i \ln Y_j,$$

where

C is total cost,
Y_i is the volume of output I,
P_j is price of input j.

Scale elasticity coefficients with respect to the two outputs are calculated as follows:

$$e_1^C = \frac{\partial \ln C}{\partial \ln Y_1} = \alpha_1 + 2\gamma_{11} \ln Y_1 + \gamma_{12} \ln Y_2 + \sum_j \gamma_{j1} \ln P_j \quad (2)$$

$$e_2^C = \frac{\partial \ln C}{\partial \ln Y_2} = \alpha_2 + 2\gamma_{22} \ln Y_2 + \gamma_{12} \ln Y_1 + \sum_j \gamma_{j2} \ln P_j \quad (3)$$

Economies of scale S at the point Y_1, Y_2 of the output set are defined by the inverse of the elasticity of Ray average cost with respect to both outputs:

$$1/S = e_1^C(Y_1, Y_2) + e_2^C(Y_1, Y_2) \quad (4)$$

It is often useful to consider the scale economies along a particular expansion path, eg defined by $Y_1 = f(Y_2)$ (see eg Baumol etal 1988). Later in this study, we will estimate a loglinear expansion path for stock exchanges.

If it turns out that the higher order terms as well as the cross-terms in the translog model are zero, the translog function is reduced to the special linear case, ie the linear logarithmic Cobb-Douglas cost function. The linear logarithmic model to be estimated is in that case

$$\ln C = \ln k + (\alpha_1 / r) \cdot \ln Y_1 + (\alpha_2 / r) \ln Y_2 + \sum_i (\beta_i / r) \ln P_i \quad (5)$$

with $\alpha_1 + \alpha_2 = 1$ and S = r.

As r is a constant, returns to scale cannot vary with the level of output in this model.

Measurement issues

In the literature reviewed in the first section, the processing of fairly homogeneous transactions and evaluation of issuer-specific complex information were seen as two separate functions. It was argued in section 2 that stock exchanges do in fact have two different operative functions, ie trade processing and firm-specific contacts. Thus stock exchanges seem to have two outputs.

It is important to find proxies for the outputs in order to test empirically whether there are economies of scale with respect to them and whether the cross-term parameter are statistically significant. Knowing this may turn out to be highly relevant as the stock exchange environment is changing rapidly, at least in Europe and the US. Proxies for the output of the trading system are fairly obvious since data are available on number and value of executed transactions. The output relating to the listing procedure of companies and monitoring of company-specific information is more difficult to measure. Possible proxies for this output might be number and value of listed companies.

Table 2. **Total costs by function, 1997**

	Staff	Premises occupancy	Systems	Administration	Depreciation	Other
Asia	30.0	12.3	17.1	15.1	9.9	15.6
Europe	35.1	7.8	18.9	7.2	12.2	18.7
North America	43.4	4.7	17.3	13.9	8.3	12.3
South America	20.6	7.9	8.5	23.0	12.1	27.9

Source: FIBV 1997, Annual Report

There are no direct measures available for inputs of stock exchanges. The two most important input prices for the operations of stock exchanges (see table 2), are trading system and labour costs. The relative share of system costs seems to be almost identical across continents, except for South America. Thus it is not likely that one could find enough dispersion in the data to get statistically significant results in the empirical analysis, even if data on prices of such inputs were available, which they are not. Individual stock exchanges are not generally able to report their costs by activity (see also FIBV 1997), which makes it difficult to get detailed statistics on their cost structures. However, one reason for homogeneous system costs may be that the exchanges use fairly similar computer hardware and software, which is similarly priced internationally. Labour costs fluctuate more across continents. Unfortunately, data on cross-country labour costs for stock exchanges are not available in Annual reports (see Annual reports 1997). In order to include at least one price input variable in the analysis, I will use GDP per capita as a proxy for differencies in labour costs across countries.

Some of the stock exchanges have expanded their operations to include derivatives and settlement business. Many of the stock exchanges do not publish sectoral cost figures. This is why the model to be estimated is a version of the translog model that always includes a dummy variable for those exchanges whose business activities include derivatives and securities settlement, in addition to two outputs and one input parameter.

4 Description of the data

I could not find a single empirical study testing for economies of scale in stock exchange operations. This is probably because of the lack of data on costs of individual exchanges and the limited number of institutions, even in global terms. The data for this study were acquired by ordering annual reports from 45 stock exchanges, of which 37 replied after four rounds (see Annual Reports 1997).[3] Although the information content of the reports varies, we were able to get the necessary information on operating costs and depreciation. The exchanges also vary institutionally. Sixteen of them also engage in derivatives business and seven are involved in settlement of stock trades. Costs of these operations are included in the data and a dummy is used to capture this information. The sample of 37 stock exchanges shown in annex gives global coverage for the data since it includes exchanges from four continents and the Pacific area and from all the major exchanges.

Data on output of exchanges were found in the International Federation of Stock Exchanges (FIBV) Annual Yearbook (1997). As stated in sections 2 and 3, the stock exchanges may have two outputs, one being the operation of trading systems so as to match and execute transactions. To capture this output, I use total number of transactions in stocks and mutual funds as well as the value of these transactions. Stock exchanges also handle the listing procedure for companies and work continuously with firm-specific information by eg releasing news and monitoring whether companies follow the regulations set for the marketplace.[4] I approximate this output by using data on number and market value of listed companies.

The annex shows output statistics of the stock exchanges that are analysed in this study. NYSE was by far the world's biggest market place as measured by value of listed equities. On the other hand, NASDAQ has twice as many listed companies as the NYSE and LSE. Value of share trading is highest on the NYSE, with the NASDAQ clearly in second place. Somewhat surprisingly, the largest number of transactions was executed in Taiwan in 1997.

An interesting, but not really empirical, look at efficiency differences between a set of fairly efficient stock exchanges is provided by table 3. The table shows that both small and big exchanges can in principle be efficient because eg the NYSE, LSE, the Irish Stock Exchange and the Taiwan Stock Exchange all have very good performance figures. One should bear in mind that costs of stock exchanges marked in the annex with * include also costs of derivative operations and those marked ** include costs of securities settlement activities. Direct efficiency comparisons can be made only between stock exchanges with the same institutional structure. In the empirical analysis a dummy variable accounts for derivatives and settlement system-related costs in the cross-section of costs. The highest costs were generated in the NASDAQ (the Tokyo Stock Exchange had

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[3] Fiscal year is not the same as the calendar year in every country. Therefore the cost data for some exchanges is from 6/1997–6/1998.

[4] Small exchanges tend to do this more than the bigger ones. This may imply that regulators in large countries regulate and monitor more by themselves than do regulators in smaller countries.

higher costs, but the figure is not comparable because it includes costs from the derivatives exchange).

Another useful look at the data is provided by figures 1 and 2. Figure 1 indicates that there are fairly pronounced returns to scale in the value of trading.

On the other hand, figure 2 suggests that either there are no economies of scale at all or they are quite small for activities involving company-specific information.

Table 3. **Performance figures for a set of selected stock exchanges, 1997**

	Costs / NTRADE	Costs / VTRADE	Costs / VCOM	Costs / NCOM
North America				
NASDAQ	5.7	0.13	0.33	102.9
NYSE	4.8	0.09	0.06	186.1
Europe				
Irish	5.0	0.08	0.03	29.7
London	11.8	0.06	0.06	114.7
Paris TSV	2.9	0.26	0.16	114.7
Asia, Pacific				
Taiwan	0.9	0.11	0.47	374.4

NTRADE is number of trades
VTRADE is value of trades
VCOM is value of companies
NCOM is number of companies

Figure 1 **Costs and scale of stock exchanges**

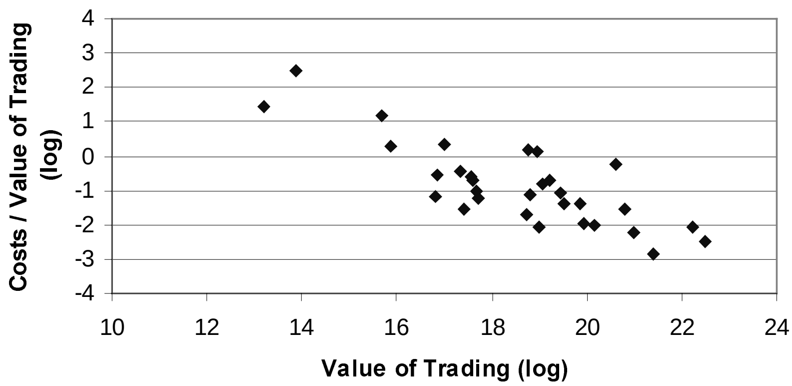
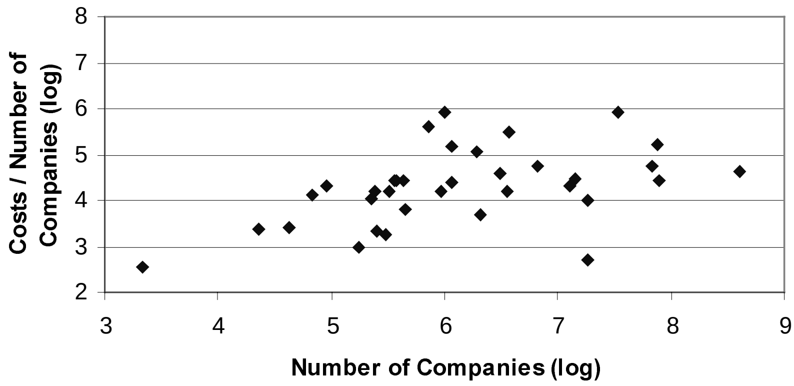


Figure 2 **Costs and number of listed companies**



5 Empirical results

It is first necessary to choose which proxies of the two outputs to include in estimation of the translog costs function. The choice is based solely on statistical considerations. I regressed the costs (C) separately on the number (NTRADE) and value (VTRADE) of transactions and the number (NCOM) and total value (VCOM) of listed companies, with a dummy (D).[5] The model was in logarithmic form. Table 4 shows that a regression with NCOM and VTRADE has a higher coefficient of determination than any other combination of the explanatory variables. Thus I use value of transactions and number of companies as output variables in the translog model. One could argue that number of companies is also logically a better estimate for the amount of work within the exchanges when listing of companies and company-specific information is concerned. The choice between number and value of transactions is more difficult to argue on a priori grounds, but fortunately the empirical results in terms of explanatory power are clear.

[5] The dummy variable is included because of those exchanges engaging in business activities involving derivatives and securities settlement. If costs of these operations are included in the total costs used in this study, the dummy takes the value 1.

Table 4. **Costs regressed on output proxies, logs**

	1	2	3	4
Intercept	−0.802	−2.27	−1.105	2.305
	(0.64)	(1.32)	(0.74)	(3.47)
NTRADE			0.349	0.282
			(2.66)	(2.47)
VTRADE	0.353	0.408		
	(3.16)	(1.29)		
NCOM	0.765			0.937
	(3.79)			(4.97)
VCOM		0.270	0.450	
		(0.78)	(4.00)	
D	0.245	0.522	0.457	0.090
	(1.20)	(1.93)	(1.78)	(0.36)
R^2	0.905	0.825	0.845	0.867
$\chi^2(2)$	1.225	0.477	0.826	0.372
N[a]	34	35	32	33

All estimates are OLS estimates; the jackknife heteroscedasticity-consistent t-ratios (see MacKinnon and White 1985) are inside parentheses under corresponding coefficient estimates. The normality χ^2 test for residuals is not rejected at reasonable significance levels.

[a] All the regressions were run also for a sample of 32 stock exchanges. The resulting R^2s were 0.905, 0.816, 0.845 and 0.868.

The translog model usually includes a few input price variables. Direct price information on the inputs was not available since stock exchanges do not publish information on them.[6] I use GNP per capita (GNBC) as a proxy for overall country cost levels in order to include at least one price variable in the analysis. The translog model given by equation (1) is thus to be estimated as

$$\begin{aligned}\ln C = \ln\alpha_0 + \alpha_1 \ln Y_1 + \alpha_2 \ln Y_2 + \tfrac{1}{2}\gamma_{11}(\ln Y_1)^2 + \tfrac{1}{2}\gamma_{22}(\ln Y_2)^2 \\ + \beta_1 \ln P_1 + \tfrac{1}{2}\gamma_{11}(\ln P_1)^2 + \gamma_{12}\ln Y_1 \ln Y_2 + \sum_j \gamma_{ij} \ln P_1 \ln Y_j + D,\end{aligned} \tag{6}$$

The outcome of the estimation of equation (6) is presented in table 5 in the first column (model 1). None of the related price variables are statistically significant at reasonable significance levels. Therefore I tested whether these terms can be dropped. The F-test value in the second column of table 6 indicates that estimated coefficients for BKTC-related variables are insignificantly different from zero. The translog model now is reduced to a six-parameter model, which is convenient, considering the number of observations. The estimation results of model 2 are in the second column. It is interesting to note that the cross term is not statistically significant, implying that the two outputs of stock exchanges do not have synergies. The F-test was next performed as above for the exclusion of second order terms and the cross term (VTRADE*NCOM) in model 2, but the hypothesis

[6] This finding is stated also in FIBV (1997).

that these terms equal zero was rejected. However, the simple linear model (3) also performs very well according to the model specification statistics.

Table 5. **Estimation results from the translog and linear logarithmic models**

	Model 1	Model 2	Model 3	Model 4
Intercept	4.224	7.769	–0.802	–0.813
	(0.23)	(1.82)	(0.64)	(0.78)
VTRADE	–0.661	–1.423	0.353	0.373
	(0.42)	(2.32)	(3.16)	(4.13)
$VTRADE^2$	0.033	0.040		
	(0.76)	(1.14)		
NCOM	1.431	3.206	0.765	0.704
	(0.46)	(3.63)	(3.79)	(4.50)
$NCOM^2$	–0.362	–0.290		
	(1.42)	(1.43)		
GNPC	0.378			
	(0.13)			
$GNPC^2$	–0.022			
	(0.17)			
VTRADE*NCOM	0.086	0.058		
	(0.42)	(0.35)		
NCOM*GNPC	0.219			
	(0.71)			
VTRADE*GNPC	–0.068			
	(0.43)			
D	0.291	0.267	0.245	0.301
	(1.31)	(1.39)	(1.20)	(1.60)
R^2	0.940	0.938	0.905	0.963
$\chi^2(2)$	0.590	1.619	1.225	0.951
N	34	34	34	33
F	0.27[a]	4.97[b]		

Estimates for Models 1–3 are OLS estimates; the jackknife heteroscedasticity-consistent t-ratios (see MacKinnon and White 1985) are inside parentheses under the coefficient estimates. The normality χ^2 test for residuals does not imply rejection at reasonable significance levels. Estimates for model 4 are WLS estimates; the t-ratios are White heteroscedasticity-consistent

[a] F-test for parameter restrictions on estimated coefficients of all the GNPC variables = 0 in model 1.

[b] F-test for parameter restrictions on estimated coefficients of both of the higher order variables and the cross-term = 0 in model 2.

Finally, the linear model is re-estimated by weighted least squares using the market capitalization (VCOM) as a weighting variable (model 4). The coefficients do not change much but the coefficient of determination is as high as 96.3 %, ie this very simple linear model is able to explain almost all the variation in the costs of exchanges around the world. It is also clear that the results are not dominated by the large number of small stock exchanges in the estimations.

The estimation results of the translog model without price terms are in column two. The scale elasticity at the sample median is obtained by differentiating the estimated model with respect to the output variables VTRADE and NCOM and calculating the elasticity by applying the estimated coefficients from table 6. The corresponding median[7] scale elasticity coefficients are 0.38 with respect to the value of trading, ie implying that the costs will increase by 38 % if the value of transactions is doubled, and 0.76 with respect to the number of companies (see table 6). This implies that there are significant scale economies involved in trading operations. On the other hand, the costs will rise by 76 % if the number of companies is doubled, ie scale economies exist also in the processing of firm-specific information but to a lesser extent. This is reasonable since the listing procedure and communication with the listed companies require either manual work or personal contacts. However, doubling both outputs does not pay off because the implied increase in costs is 114 %, which is fairly close to constant costs.

Comparison of the estimation results with the outcome of the linear model is also very interesting. The average elasticity coefficient for value of transactions is almost the same (0.35) as in the translog model. The corresponding coefficient for the number of companies (0.77) is almost identical with that of the translog model. The dummy variable is not statistically significant in either of the regressions. Nevertheless, its size is very stable (0.24–0.30) in all four estimations. This indicates that costs will increase by about 30 % if an exchange initiates derivatives exchange and securities settlement operations. This figure is somewhat lower than one might expect from looking at annual reports of derivatives exchanges and central settlement entities. On the other hand, many stock exchanges that own a derivatives exchange have only a very limited set of derivative products. Furthermore, settlement is usually provided only for stock trades, which may explain the unexpectedly low coefficient.

In order to gain a better understanding of the cost elasticities, table 6 provides some additional analysis on four points of the two outputs of stock exchanges (see equation 4). This was done by ray average cost (Ray) analysis (see eg Baumol etal 1988), starting as usual by estimating a loglinear expansion path for the stock exchanges, lnVTRADE = f(lnNCOM). I constructed four groups according to exchange size, the number of listed companies beeing used as a proxy for size. The median number of companies was selected next for each group as its representative output. Value of trading at this point was forecast by using the outcome of expansion path estimation (see table 6, footnote 2). The scale elasticity with respect to each output is reported in the table as is the Ray average cost (S). The inverse of S is the scale elasticity of the combination of the two outputs.

[7] I use number of the listed companies as a ranking variable. The sample is skewed, as there are few very big stock exchanges with a large number of companies listed (see table 3). Therefore, the median is preferred to the mean.

Table 6. **Estimated Ray average cost and multiproduct scale economies in translog and loglinear models**

Size	COM [1]	VTRADE [2]	e^{c}_{COM} [3]	e^{c}_{VTRADE} [4]	e^{c}_{RAY} [5]	S [6]
Q1	143	14 521	1.285	0.186	1.471	0.680
Q2	283	40 833	0.950	0.308	1.258	0.795
Q3	608	130 612	0.573	0.446	1.019	0.981
Q4	1865	717 369	0.021	0.648	0.669	1.495
Median	416	73 493	0.760	0.378	1.138	0.879
Loglinear model			0.765	0.353	1.118	0.894

[1] Median number of companies in each quarter.
[2] Expected value of trading in the median exchange, in billions of US dollars according to the estimated expansion path for stock exchanges, lnVTRADE = 8.95 + 1.52 lnNCOM.
[3] Scale elasticity coefficient of costs with respect to number of companies (equation 2).
[4] Scale elasticity coefficient of costs with respect to value of trading (equation 3).
[5] Ray scale elasticity coefficient with respect to both outputs, COM and VTRADE (equation 4).
[6] Inverse of e^{c}_{RAY} .

The outcome of the analysis is somewhat surprising. It is very clear that there are considerable returns to scale for an increase in the value of trading in the first group, ie in the smallest stock exchanges. On the other hand, costs increase by 129 % if the number of listed companies is doubled. This analysis also clearly suggests that mergers or very intense alliances of small exchanges do not save costs. The situation is exactly the opposite for the biggest stock exchanges. Doubling of both outputs increases costs by only by some 67 %. The analysis actually shows that scale economies in stock exchanges are an increasing function of size. Thus it is very cost efficient for the biggest exchanges to expand further. Smaller exchanges should seek primarily to increaseing their trading volumes.

The analysis also raises the question of the pricing of services. Due to their nonoptimal size, it seems to be the case that small exchanges have been able to price their services so as to cover their high costs, thanks to their monopolistic market position. The market power of stock exchanges is of course diminishing rapidly.

The results raise some further concerns about the accuracy of the specification of the estimated model. The quadratic form of the model may not necessarily be able to very accurately describe the performance of stock exchanges broken down into in widely differing size classes. Therefore one should draw only tentative conclusions from the analysis.

Table 7. **Relative efficiency of individual stock exhanges**[1]

	Model 2		Model 3
Philippine	–0.816	Estonia	–0.909
New Zealand	–0.770	Philippine	–0.777
Hong Kong	–0.607	New Zealand	–0.707
Montreal	–0.546	Toronto	–0.645
Toronto	–0.489	Irish	–0.609
NYSE	–0.456	Vancouver	–0.590
Madrid	–0.304	Montreal	–0.513
Switzerland	–0.274	Germany	–0.485
Irish	–0.258	Nasdaq	–0.396
Vancouver	–0.213	Hong Kong	–0.375
Germany	–0.174	Madrid	–0.228
Stockholm	–0.173	London	–0.183
London	–0.144	Australian	–0.166
Kuala Lumbur	–0.133	Stockholm	–0.157
Ljubljana	–0.021	Kuala Lumbur	–0.111
Australian	0.003	Helsinki	–0.083
Paris	0.035	NYSE	–0.066
Estonia	0.040	Oslo	0.013
Jakarta	0.061	Switzerland	0.017
Oslo	0.073	Copenhagen	0.061
Copenhagen	0.076	Jakarta	0.100
Nasdaq	0.107	Paris	0.136
Brussels	0.120	Athens	0.140
Athens	0.142	Osaka	0.144
Sao Paulo	0.215	Brussels	0.159
Helsinki	0.225	Sao Paulo	0.339
Taiwan	0.273	Thailand	0.370
Thailand	0.281	Ljubljana	0.545
Luxembourg	0.301	Amsterdam	0.657
Osaka	0.319	Warsaw	0.672
Amsterdam	0.505	Taiwan	0.718
Warsaw	0.668	Amex	0.950
Amex	0.911	Tokyo	0.960
Tokyo	1.022	Luxembourg	1.022

[1] The coefficients are residuals from models 2 and 3 in table 5, listed in decending order so that stock exchanges with the biggest negative coefficients are the most efficient ones. Note that this analysis omits returns to scale, ie accurate comparisons between exchanges can be made only for same-size exchanges. The correlation for the residual series is 0.82.

It is also useful to analyse the relative operative efficiency of stock exchanges. One can provide some preliminary analysis based on the results shown in table 6. Residuals of the estimated models 2 and 3 provide us with some indicative information on the efficiency of the individual stock exchanges (see table 8). One should note that the log of the residuals provides us only with information on the deviations from the estimated ’average’ cost performance. This information does not take into account returns to scale, ie it is only possible to compare stock exchanges that are of the same size. Therefore efficient frontier analysis would be a natural topic for future research. In spite of the limitations of the analysis, it provides the very useful finding that stock exchanges of equal size seem to have extreme differences in efficiency. This should raise some thoughts (and action) in the exchanges that find themselvels at bottom of the table. Owners of the AMEX have actually drawn their conclusions already as evidenced by the AMEX-NASDAQ merger.

6 Policy discussion and conclusions

Summary of the study

My empirical study included 37 stock exchanges from four continents, using data on operating costs, depreciation and outputs for 1997. I found that there are two functions performed by stock exchanges. They have computers, software and personnel for matching and processing trades. This is the trading function. The second function of stock exchanges is to provide the personnel and regulations needed to maintain the marketplace and to communicate with companies in order to handle the listing of companies and to monitor company-specific information releases.

I estimated the most common linear and nonlinear cost functions in order to determine whether scale advantages exist in the two outputs of stock exchanges. The trading system-related output was approximated by number of transactions and value of transactions. Output related to the listing procedure and to other activities involving company-specific information was approximated by the number of listed companies and the capitalisation of companies listed on each stock exchange.

According to the study, the trading function clearly entails economies of scale. The function related to the listing procedure and to other activities involving company-specific information has less returns to scale. However, returns to scale on the second function are very significant in the biggest stock exchanges.

There are thus opposing forces, some toward increasing standardization and scale and others toward the continued existence of more localized facilities. The outcome may be not be complete amalgamation of exchanges but instead centralization of certain functions, such as the trading function, and continued decentralized conduct of other operations.

The overall scale elasticity for stock exchanges is greater than 1.0, which means that costs would more than double if both number of companies and value of trading in an exchange were simultaneously doubled. In other words, the area of economies of scale covers only certain rays. This implies that it is not at all self evident that the pooling of all activities would save costs. However, analysis show that returns to scale exist in the combined operations of the biggest exchanges. By contrast, with the small and medium sized stock exchanges, the poling of activities does not save costs. In my sample of stock exchanges, the value of trading is tripled on average when the number of companies is doubled.

My results suggest that the trading function argues for the formation of alliances whereas the firm-specific information function is supportive of local knowledge and institutions. The overall result will be a balance between these.

Apparently, there are no economies of scale for the two functions taken together, except in respect of big exchanges. Therefore forming alliances that seek to utilize returns to scale specifically in their trading systems may be a good way to handle the two functions simultaneously. This analysis, along with some findings on the US stock market, forms the basis for several policy recommendations on the establishment of alliances in Europe or elsewhere.

Policy recommendations and discussion of the trading system

In the light of these empirical findings, it seems clear that European stock exchange alliances should aim at least to **standardize the technology** used in trading systems. It would probably be optimal to **centralize the trading system** so as to maximize scale economies in the processing of trading. If complete centralization of the trading system is to be carried out, there will have to be agreement on the principle for sharing costs and income between stock exchanges. This agreement should be negotiated so as to better enable the formation of the one or two Pan-European alliances. The US type of mergers of stock exchanges may occur also in Europe as the harmonization of legistlation proceeds and the pressure on existing structures increases.

Economides and Siow (1988) have shown that liquidity considerations will limit the number of markets in a competetive economy. In their spatial competition model with liquidity as a positive externality, there may be too few markets because nobody wants to use a new market with low liquidity. Later, Economides (1993) showed that networks (such as electronic trading systems) are by their nature self-reinforcing. As a consequence, networks exhibit positive critical mass. A second consequence is that optimality will not result from perfect competition. According to Economides, this opens the possibility that some market structures (such as monopoly) which can coordinate expectations, might achieve larger networks and higher welfare than would perfect competition.

A third observation is that network providers have market power through the setting of standards for the network. Stock exchanges usually set rules and regulations on their trading systems. This, according to Economides (1993), impedes technological innovation. The papers by Economides and Siow (1988) and Economides (1993) provide substantial motivation for authorities and the investment community to ensure that the coming pan-European alliance or alliances do not act as a price cartel or use their market power to impede competition, ie **free entry at reasonable costs should be ensured** in one way or another to allow for competition with the existing infrastructure and with possible new enterprises at each point of time.

Economides (1993) also discusses another relevant issue that is of importance for the interpretation of the analysis provided in this paper and for the policy discussion. He argues that equilibrium price information from a financial exchange network is another externality, in addition to the market liquidity discussed above. As the validity of the market price established in a network X is an increasing function of the size of the network, it may be better for a small network Y to use the price information provided by the network X instead of engaging at all in price discovery itself. As more customers switch to network Y, the validity of the market price in network X is reduced, according to the argumentation in Economides (1993).

This question was analysed empirically by Bessembinder and Kaufman (1998). They examined execution costs for trades in stocks listed on the NYSE and trades executed on the NYSE, the NASD dealer market, and the regional stock exchanges during 1994. NYSE members are allowed under SEC rule 19c-3 to compete with NYSE spesialists by executing trades in NYSE-listed firms in off-exchange systems. They found that some off NYSE exchanges have specialized in attracting small trades in the shares of large NYSE-listed companies. A concern here stems from their observation that exchanges other than the NYSE are actually cream skimming as some of them concentrate on trades that take advantage of price discovery in the NYSE. They also found that realized bid-ask spreads are higher for shares that are subject to cream skimming. Thus the validity of the NYSE market price seems to be reduced as customers (brokers) switch to alternative networks. The problem of course is that this is not necessarily in the interest of end investors, as the spreads are wider and quality of the market price worse. A solution suggested by Economides (1993) is to price market equilibrium information appropriately. This question relates to legistlation and interim rules and regulations as well as microstructure of trading systems of stock exchanges and specifically those of alliances.

Policy recommendation regarding the listing procedure and other activities involving company-specific information

It may be optimal to keep the company-specific-information-related functions close to the source of original information, ie in the local exchanges. This is the case because little or no scale advantages were found exept in very big exchanges. Furthermore, differences in language and culture also reduce the quality of communication if these activities are centralized. On the other hand, total harmonization eg of listing rules and other regulations might save a lot money as no returns to scale were found in these activities, at least in small stock exchanges. In the light of discussion above, it also makes sense that at least the Frankfurt-London alliance should seek to withdraw multiple listings so as to maximize liquidity and minimize multiple listing costs.

Conclusions

This study underlines the need for European stock exchanges to quickly proceed with cooperative efforts. Formation of alliances might be a good way to start the consolidation process among European stock exchanges. Alliances are needed, and they should lead to significant cost reductions. On the other hand, scale economies do not exist in all operations of exchanges, except perhaps in the very largest marketplaces. Therefore it may be that it is optimal to search for function-specific scale advantages by establishing a standard for trading systems or even by centralizing them. At the same time, it may be optimal to leave the listing process, as well as other connections with companies, and news releases to the national stock exchanges.

It was found that scale economies exist only in the very large exchanges but that there are significant scale economies with respect to the processing of trades. It is therefore obvious that the coming European alliance(s)/exchange(s) should need to be big enough to enable them to compete with the New York Stock Exchange as regards the listing and trading volume of the leading companies in the world. Many intercontinental mergers of listed companies have already been announced.

The empirical findings of this paper were also discussed with respect to some theorethical and empirical findings of other papers. It was found that legistlation and interim regulation of stock exchanges, as well as the microstructure of the trading sytem, are important elements of a liquid and efficient trading environment. It is also clear from the public policy point of view that it is necessary to ensure that competition is not diminished by marketplace rules and regulations.

Suggestions for further research

Data in this study covered only one year. Even though it was very time consuming to obtain the data used in this study, it would be useful to get time series of data as well as even better coverage. Efficient frontier analysis would give further insight into relative efficiencies of individual stock exchanges. Use of alternative pricing of outputs of exchanges would allow one to analyse the optimal pricing policy of stock exchanges, and suchanalysis would certainly increase our understanding of stock exchanges.

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Annex. **Output statistics for individual stock exchanges, 1997**

	Value of trading USD m	Number of transactions 1000	Market value Of companies USD m	Number of companies listed
North America				
Amex*	143230	5001.5	124606	710
Montreal*	44689	1934.6	422694	557
NASDAQ	4481682	98960.4	1737510	5487
NYSE	5777602	102550.4	8879631	2626
Toronto*	305155	11142.2	567635	1420
Vancouver**	6470	2081.2	6615	1429
South America				
Sao Paulo**	190658	1871	255478	537
Europe, Africa, Middle East				
Amsterdam**	280901	3798.6	468897	348
Athens	21137	3733.3	33784	210
Brussels**	33867	2300	138938	265
Budapest*	7039	Na	14700	na
Copenhagen	46732	1018.9	93766	249
Estonia	1573	122.4	1139	28
Germany*	1067688	27815.5	825233	2696
Helsinki	36252	568.1	73322	126
Irish	17301	261.3	49371	102
Italy	203280	11051.7	344665	239
Ljubljana	544	131.4	1876	78
London	1989489	9673.4	1996225	2513
Luxembourg	1048	47	33892	284
Madrid	138737	7891.8	290383	388
Oslo	49601	829.8	66503	217
Paris	414321	37000	676311	924
Prague	6260	na	10817	Na
Stockholm	175822	4836	264711	261
Switzerland*	568882	6130	575339	428
Warsaw	7953	3500	12135	143
Asia, Pacific				
Australian*	171004	6141	295411	1219
Hong Kong*	453657	32601	413323	658
Jakarta**	42605	2972.5	29050	281
Tokyo*	896055	Na	2160585	1865
Kuala Lumbur	145688	21580	93182	703
New Zealand	10725	517.1	29889	190
Osaka	221990	1834	Na	1275
Philippine**	20350	1850	31212	221
Taiwan	1308634	154345	296808	404
Thailand**	24599	8730	22792	431

* Costs include costs from derivative exchange activities
** and securities settlement

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