BANK OF FINLAND DISCUSSION PAPERS

20/2000

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Research Department

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Are Expansions Cost Effective for Stock Exchanges? A Global Perspective

SUOMEN PANKIN KESKUSTELUALOITTEITA • FINLANDS BANKS DISKUSSIONSUNDERLAG

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Abstract

This paper investigates the existence and extent of economies of scale and scope among stock exchanges. Evidence from 38 exchanges in 32 countries and 4 continents around the world for the years 1989–1998 indicates the existence of significant economies of scale and scope. The degree of such economies however differs by size of exchange and region. The largest stock exchanges show an increasing trend of cost effectiveness. Exchanges in North America and Europe report substantially larger economies of scale than those in the Asia-Pacific regions.

Keywords: stock exchanges, mergers, regional alliances, economies of scale.

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

Lisääkö pörssien kasvu niiden kustannustehokkuutta? Globaali näkökulma

Suomen Pankin keskustelualoitteita 20/2000

Iftekhar Hasan – Markku Malkamäki
Tutkimusosasto

Tiivistelmä

Keskustelualoitteessa tarkastellaan, missä määrin pörssien toimintaan liittyy suurtuotannon ja yhteistuotannon etuja. Analyysi perustuu vuosilta 1989–1998 koottuun aineistoon 38 pörssistä. Nämä pörssit sijaitsevat 32 eri maassa ja neljässä eri maanosassa eri puolilla maailmaa. Aineistosta ilmenee, että suurtuotanto- eli skaalaedut ovat merkittäviä, joskin niissä on pörssien koosta ja sijainnista johtuvia eroja. Suurimpien pörssien kustannustehokkuus näyttää jatkuvasti kohenevan, ja pörssitoiminnan skaalaedut ovat huomattavasti suurempia Pohjois-Amerikassa ja Euroopassa kuin Aasian Tyynenmeren alueilla.

Asiasanat: pörssit, fuusiot, alueelliset yhteenliittymät, skaalaedut

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

Contents

1 Introduction

In recent decades we have witnessed massive consolidation and evolution of financial services, institutions, and markets. The ever-evolving technology and a changing regulatory environment were the fundamental forces behind these changes, shaping the global market of the future. In the security industry, the trend has been also towards the merging (Arnold et al. (1999)) of markets. Technological advancement have reduced physical market access costs as well as information costs causing less dependency on physical locations of markets thus exposing local stock markets to an increasingly competitive pressure from rival exchanges. Indeed, the exchanges are facing strategic challenges as debates and analyses continue in the profession regarding the future of the market and globalization (Smith (1991), Gehrig (1998b), Malkamäki and Topi (1999), and Stulz (1999)).

A key issue that have emerged in the forefront of stock exchange analysis is whether the existence of a significant economies of scale in the functions of stock exchanges would lead to the emergence of a single market or a few super regional markets for securities in the years to come? Pirrong (1999) presents a model that predicts that economies of scale will encourage consolidation among stock exchanges until profitable entry into liquidity provision is eliminated. This conclusion represent a further reflection and support to early research by Doede (1967), Demsetz (1968) and Kindleberger (1974) claiming the potential existence of economies of scale among exchanges. The handling of complex information may require face-to-face contacts and hence motivate the existence of multiple market places for securities (Gaspar and Glaeser (1996)). Some argue that as long as small market frictions (access cost and heterogeneous information) exist, the relevance of geography would persist. (O'Brien (1992) and Gehrig (1998a)). Others claim that the barriers to capital flows and differences of price of risk across markets will continue to delay any integration (Korajczyk (1997)).

Nowadays, the increasing use of innovative technology, actual and potential agreements on mergers and co-operations among exchanges is forcing policy makers and market players to better understand the recent global developments in the markets for equity exchanges and the costs associated with it.[1] In the finance literature, a number of studies have focused on the benefits of trading cost to investors from cross-exchange comparison of execution costs (Bessembinder and Kaufman (1997)) and on the impact of competition for order flows (Arnold et al. (1999)). Recently, Malkamäki (1999) tested for the existence of economies of scale among exchanges using a cross-sectional data for 1997 reporting the presence of scale economies only among the very large exchanges.

While much attention has been focused on the emergence of new technologies on the economies of scale and scope of banking (Berger and Humphrey (1997)), not much effort has been given to finding the actual scale and scope perspectives among stock exchanges. The lack of availability of consistent global panel data on

[1] The recent success of EUREX is a good European example of how networks are able to replace a trading floor in another country. This example together with developments evidenced on a global scale in the currency and bond markets implies that technology is already sufficiently advanced and cheap to enable investors to trade via networks. This, in turn, 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 and globalise.

operational costs across stock exchanges is likely to be the key factor behind such lower attention.

This paper attempts to void the gap in the literature with a comprehensive attempt to evaluate the economies of scale and scope issues across 38 exchanges around the world over the 1989–1998 period. This is one of the first comprehensive attempts in comparing the actual operating costs across markets with regional focus. Following Arnold et al. (1999), Domowitz and Steil (1999) and Pirrong (1999), stock exchanges are considered as operative firms. This approach is of great importance for the evolution of the market structures and contestability of the markets because stock exchanges make choices concerning, for example, their trading technologies i.e. the supply side of their trading services.[2]

The overall results of this study reveal the existence of substantial economies of scales among stock exchanges. Exchanges that are located in regions with relatively more harmonised regulatory structure and are committed to spending relatively higher proportion of resources in human capital and trading systems – e.g. North American exchanges – are more to gain from such expansions and cost savings. A sub-sample of European exchange also reports a somewhat similar result portraying economies of scale. While, Asian and Pacific region with less co-ordination and harmonization effort among themselves are experiencing diseconomies of scale. The existence of economies of scale is more prominent among largest exchanges however such strong economies of scales are not present among the smallest exchanges. Similar results are found for the economies of scope estimates where exchanges especially in North America and Europe enjoy substantial benefit from multi-task production.

The paper is organized as follows: Section 2 presents a brief review of the literature related to scale and synergy issues related to stock exchanges and stock market integration. Section 3 narrates the recent operations and performance of stock exchanges around the world followed by the cost function model, specification and measurement issues in section 4. Section 5 describes the data and section 6 contains empirical results. Section 7 summarizes the findings and provides policy recommendations.

2 Relevant literature review

There are some studies that have focused on scale economies in information processing and the future of financial centres. Doede (1967) published one of the first studies elaborating on the scale economies in securities markets. He reported that the average operating costs of stock exchanges are a declining function of trading volume, and indicating evidence of economies of scale in exchange. Demsetz (1968) analysed data from the bid-ask perspective showed that the spreads are a declining function of the rate of transaction volume, again indicating economies of scale in the market making of a particular security. Recently, Smith (1991) analysed the incentives and potentials of globalisation of financial markets

[2] Domowitz and Steil (1999) argue further that industrial structure of market places can not be explained by focusing on the demand side alone as in financial market microstructure studies that concentrate on the characteristics of trading systems and the demand side of trading services i.e. the traders.

highlighting the declining marginal cost of information and the benefits of integrated markets.

While emphasising the optimal location perspectives, Davis (1990) claimed that the innovation in technology and the uniformity of regulation in the EU countries is likely to lower entry barriers and foster competition among local financial centres and hence reduce existing monopolies. The 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 argued that straightforward information could be easily transferred through electronic networks. However, with complex information, the instructions may be easily misunderstood, hence face-to-face communication is required. Their empirical work showed that telecommunications might in fact be a complement, or at least not a strong supplement for financial centres. Their analysis contradicted prevalent argument that telecommunications will eliminate the significance of location.[3]

Grilli (1989), Krugman (1991) and Gehrig (1998b) focused on the importance of understanding competition among financial centres. These papers claimed that as integration of world market is rapidly proceeding, local markets are increasingly becoming exposed to competition from rival markets. Technological condition, economies of scope and scale are considered key sources of agglomeration among markets. Gehrig pointed out that multiple markets are likely to coexist: 1) under free entry of firms and 2) when markets are large enough. He also claimed that deregulation of transaction taxes is an equilibrium reaction to a significant decline in transportation costs.[4]

Gehrig (1998a) argued that geographical dispersion of financial activity exists primarily because – contrary to the usual assumption in the literature – markets are not frictionless. Gehrig and Kindleberger (1974) divided factors underlying the development of financial centres into centripetal and centrifugal groups claiming economies of scale are the major centripetal force in payment and settlement systems as well as in currency trading systems.[5] Other centripetal forces are informational spillovers, market liquidity and thick market externalities, such as liquid labour market (Gehrig (1998a)). The centrifugal forces arise from market access costs and localization of information. Market access costs include transportation costs and transaction costs that do not depend on distance.[6] The authors claimed that centrifugal forces should be particularly relevant in the markets for instruments that are priced on the bases of complex local information, i.e. 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.

Brennan and Cao (1997) developed a model of international equity portfolio investment flows based on differences in informational endowments between

[3] For a discussion of this issue, see Gaspar and Glaesser (1996), Gehrig (1998a) and O'Brien (1992).
[4] Fiscal authority is considered as a key deglomerative force that may partially reduce the advantages of a thick market.
[5] Bauer and Hancock (1995) report significant scale economies in providing payment services in the Federal Reserve automated clearing house.
[6] For more details on this issue see, Pagano (1989).

foreign and domestic investors.[7] They showed that when domestic investors possess a cumulative information advantage over foreign investors about their domestic market, investors tend to purchase foreign assets in periods when the return on foreign assets is high and sell when the return is low.[8] Shucla and Inwegen (1995) reported higher performance of domestic mutual funds over foreign-managed mutual funds partly due to the inferior market timing by foreign funds. Brennan and Cao noted that even portfolios of US domestic mutual funds are geographically biased towards the home fund, implying that problems of distance are dwarfed by problems of languages and cultural differences between countries and complicated cross-border activities. Additionally, Grinblatt and Keloharju (2001) documents that investors are more likely to hold, buy, and sell stocks that are located close to the investor, that communicates in the investor's native tongue, and that have chief executives of the same cultural background.

Malkamäki and Topi (1999) focused on the consequences of the changes in the market structures for stock and derivatives exchanges and securities settlement systems. They stated that the business conducted by exchanges and brokers will tend to converge and be subject to increased contestability because of economies of scale and scope and network effects. The authors also reported a shift from national derivative exchanges to the EUREX (centre of trading in German bond derivatives). This development is consistent with Gaspar and Glaeser (1996) and Gehrig (1998a), as parallel concentration has not taken place in the trading of stock derivatives. Hart and Moore (1996) argued that in cooperative exchanges, members may be reluctant to accept changes that would affect their own business, even if this may not be in their own interest in the long run.

Domowitz (1995) discussed effects of network externalities and standardization for the exchange industry. He argued that common electronic trading platforms, i.e., implicit mergers between existing exchanges will emerge because of the positive liquidity effect. He also claimed that implicit mergers allow individual exchanges to set prices above marginal cost. Using one-year data, Malkamäki (1999) found that overall economies of scale exist only among the very big exchanges and suggested increasing trend of implicit mergers of exchanges in the near future.

The empirical evidence so far, however, lacks a comprehensive multiyear analysis with regional focus incorporating recent initiatives undertaken by stock exchanges around the globe. Given the differences in the degree of initiatives of consolidation, implicit alliances, and co-operation among exchanges in different regions (especially in Europe), it is important that a study provides separate perspectives for different regions. Using a panel data, for 38 key exchanges in 32 countries from 4 continents during the 1989–1998 period, this paper estimates linear and nonlinear cost functions and traces the existence and extent of economies of scale and scope among exchanges.

[7] The model discussed here is similar to that of Kang and Stulz (1994) where domestic investors are assumed to be better informed than foreign investors about the payoffs in the domestic market.
[8] For further discussion on the rationale for home country bias see Hasan and Simaan (2000).

3 Developments in stock exchange industry

Stock exchanges are primarily in the business of security listing, trading, and clearing services, i.e. match making between buyers and sellers of securities, and providing a mechanism for discovering the price information. They are also involved in making revenue for the organisers of the market (Angel (1998)). In the European and Asian context, stock exchanges have historically been local monopolies. This is in contrast with the North American exchanges, which are involved in intense competition among themselves in the US and Canada. This competition has led to a steady decline of number of exchanges in the US (Smith (1991) and Arnold et al. (1999)). In a recent initiative, the American Stock Exchange and the Philadelphia Stock Exchange merged with the NASDAQ market.

Globally, the experience has not been uniform. In recent decades, a large number of new derivative and stock exchanges have been established around the globe. In the 1990s alone, we have seen the emergence of 60 new exchanges.[9] Most of them are located in Asia-Pacific Rim and in Central and Eastern Europe. These new exchanges in emerging economies are functioning primarily in national markets and are local by nature and activities.

Financial markets also contain network externalities. A closer look at the recent evolution of equity trading systems in the United States reveals that a huge invasion of new equity routing/matching/trading systems such as Instinet, POSIT, AZ, and Attain etc. is taking place. These systems have gained increasing volumes, especially in stocks listed on NASDAQ as well as many NYSE-listed stocks.[10] This opens up the possibility of a new scenario in which economies of scales lead to further consolidation of traditional stock exchange volumes at the same time as new alternative electronic trading systems create new services and competition that may lead to fragmentation of liquidity and cream skimming.

With the emergence of the Euro, competition among the European stock exchanges has already intensified. To meet this challenge European stock exchanges are reorganising their operations in order to become more competitive. They are attempting to gain scale advantages by forming bilateral or multilateral alliances among themselves. Such alliances have existed already for some time 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; and Helsinki Exchange and EUREX. All these alliances are examples of implicit mergers. They utilise economies of scale in the trading system by using common platforms and/or even the system operated by one of the participants in the alliance. This strategy may turn out to be fruitful since Chan et al. (1997) found that in horizontal strategic alliances, more value accrues when the alliance involves the transfer or pooling of technical knowledge.

In September 1999, eight European exchanges (Amsterdam, Brussels, Frankfurt, London, Madrid, Milan, Paris and the Swiss Exchange) agreed to form an electronic market for trading of European blue chips by November 2000. The

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[9] MSCI Handbook of World Stock, Derivative, and Commodity Exchange 1999. For more details on formation of exchanges, see Clayton, Jorgensen, and Kavajecz (1999).

[10] For more details on these issues, see Bessembinder and Kaufmann (1997), Domowitz and Steil (1999), Economides and Silow (1988), and Malkamäki and Topi (1999).

alliance will be based on a common market model with common functionality, supported by a harmonised rulebook. The agreed market model is based on the following seven features:

1) Continuous electronic order driven trading, with an opening and closing auction and optional intra-day auctions;
2) Harmonised approach to access arrangements to each market/order book for each exchange's customers;
3) Pre- and post-trade anonymity and trading supported by central counter party arrangements or the equivalent;
4) Harmonised functionality for continuous trading, e.g. order types, size, use of auctions, dealing capacities, and tick sizes;
5) Functional support for hidden or "iceberg" orders, thereby facilitating block trades;
6) Common approach to preventing market or index manipulation, with each exchange supervising trading of its own alliance market securities;
7) Fair and equal market access will be fair and equal regardless of the member firms' geographic location.

The market model will provide investors with a centralised anonymous limit order book with post trade anonymity. These features are the major innovations that have facilitated the success of the ECNs (electronic communication networks) and ATSs (alternative trading systems) in the United States. However, the agreement worked out by the eight European exchanges could exploit the economies of scale in trading systems even further. The model has the potential to develop further with agreement on the use of one set of software and centralising the operation of the system. This will perhaps also at least partially come true as Benelux and Paris exchanges have decided to merge.[11] (Recently also the Swiss exchange and Tradepoint announced to form a unified London based stock exchange).

It seems that wide co-operation between European stock exchanges will be limited to trading systems and continue to be based on alliances in the short run. This could be justified, given the fact that Europe is heterogeneous with respect to language, culture, accounting principles and bankruptcy legislation. Such heterogeneity is even more significant in Asia, for example. It is therefore, very advantageous to find out which operations of local stock exchanges are subject to returns to scale and are thus more likely to be included in the co-operative activities of European stock exchanges.

A close look at the operations and annual reports of stock exchanges indicates that these institutions perform primarily two functions and produce two outputs as suggested in Malkamäki (1999). 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 literature suggests that such activities, based on very simple information, tend to be centralized. Limit orders and market orders can actually be considered standardised information, and the processing of this information is technical and not issuer-specific, i.e. all the transactions are

[11] A similar motivation perhaps was also behind the on-hold planned merger of London and Frankfurt stock exchanges.

treated in more or less the same way in the trading system. Thus execution of trades can realistically be based on technology that is standardised throughout each country or even throughout Europe as it is planned in the market model.

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 could be expensive. It might therefore be optimal that listing procedures and communication with companies and other related matters be handled by the national exchanges, even in the future. These analyses lead to the empirical question related to the existence and extent of scale economies in stock exchange operations. Scale economies of the two functions, trade processing and firm-specific contacts, are the focal point of this empirical attempt with specific attention given to the differences in operations and activities among different regions of the world.

4 The model

4.1 Specification

First, we estimate a translog cost function (see e.g. Berndt, 1991). The translog function has the nice feature of allowing scale economies to vary with the level of output. Given our goal of incorporating two outputs, the translog cost function takes a form of

$$\begin{aligned}\ln C = \ln\alpha_0 + \alpha_1 \ln Q_1 + \alpha_2 \ln Q_2 + \gamma_{11}(\ln Q_1)^2 + \gamma_{22}(\ln Q_2)^2 \\ + \sum_i \beta_i \ln P_i + \sum_i \sum_j \gamma_{ij} \ln P_i \ln P_j + \gamma_{12} \ln Q_1 \ln Q_2 \\ + \sum_i \sum_j \gamma_{ij} \ln P_i \ln Q_j,\end{aligned} \tag{4.1}$$

where

C is total cost,
Q_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

$$e_1^C = \frac{\partial \ln C}{\partial \ln Q_1} = \alpha_1 + 2\gamma_{11} \ln Q_1 + \gamma_{12} \ln Q_2 + \sum_j \gamma_{j1} P_j \tag{4.2}$$

$$e_2^C = \frac{\partial \ln C}{\partial \ln Q_2} = \alpha_2 + 2\gamma_{22} \ln Q_2 + \gamma_{12} \ln Q_1 + \sum_j \gamma_{j2} P_j \tag{4.3}$$

Economies of scale S at the point (Q_1, Q_2) of the output set are defined by the inverse of the elasticity of Ray average cost with respect to both outputs

$$\frac{1}{S} = e_1^C(Q_1, Q_2) + e_2^C(Q_1, Q_2) \quad (4.4)$$

It is often useful to consider the scale economies along a particular expansion path, e.g. defined by $Q_1 = f(Q_2)$ (Baumol et al. (1988)). Later in this study, we will incorporate the estimation of a loglinear expansion path for stock exchanges.

If 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, i.e. the linear logarithmic Cobb-Douglas cost function. The linear logarithmic model to be estimated is in that case

$$\ln C = \ln k + \left(\frac{\alpha_1}{r}\right)\ln Q_1 + \left(\frac{\alpha_2}{r}\right)\ln Q_2 + \sum_i \left(\frac{\beta_i}{r}\right)\ln P_i \quad (4.5)$$

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 type of model.

Finally, overall economies of scope (OEOS) exist if single output production is more costly than multiproduct production i.e. whether concentration in processing of trades alone is more costly than concentrating in both processing of trades and listing higher number of companies. The degree of OEOS is given by

$$\frac{\sum_{i=1}^{n}[C(0,.....Q_i,........0) - C(Q)]}{C(Q)} \quad (4.6)$$

where $C(0,\ldots\ldots Q_i, \ldots\ldots 0)$ is used as a proxy for the production costs of the single output Q_i. To use this measure, one must assume that cost structures of single- and multi-product firms are comparable. Moreover, it is known in the literature that using translog cost function to measure economies of scope is problematic. Berger, Hanweck, Humprey (1987) pointed out that the translog is undefined for zero output levels and claimed that in such scenarios, the outcomes depend on the proximity of the zero output approximation. Loglinear form of cost function also suffers from somewhat similar problems.

In order to correct such problems, we first follow Mester (1987) and incorporate ad hoc values of 0.01 as proxies for zero output levels in the translog model. Second, in the loglinear model, we use Q replacing logarithm of Q in evaluating economies of scope (Berger, Hanweck, and Humphrey (1987)).[12] Recognizing the fact that results from these estimations above are likely to be sensitive to the choices of these ad hoc parameters, or variable definitions we estimate a quadratic cost function model which doesn't have similar methodological problem (Dermine and Rollar (1992)).[13]

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[12] In both translog and loglinear models, our results are extremely sensitive to particular assumptions considered. This has prompted us to estimate alternative models.

[13] Quadratic cost function with input prices embedded in the constant term, minimizing cost subject to factor prices with a second order approximation is $C^*(Q^*) = \alpha_0 + \sum_i \alpha_i Q_i^* + \sum_i \sum_j \alpha_{ij} Q_i Q_j$, where Q*=output vector, C*Q* is total cost.

4.2 Measurement issues

The literature reviewed in this paper claim that the processing of fairly homogeneous transactions and evaluation of issuer-specific complex information are seen as two separate functions. It was argued earlier in this paper that stock exchanges have two different operative functions, i.e. trade processing and firm-specific contacts, thus they generate two outputs. We follow Malkamäki (1999) when attempting to incorporate relevant proxies for the above outputs and test whether there are economies of scale with respect to these outputs and whether the cross-term parameters are statistically significant. Proxies for the output of the trading system are fairly obvious and simple since data are consistently 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.

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 1), are trading system and labour costs. Although the system costs seem to be slightly higher in the markets from developed regions of the world however the differences are not significant except for the Sao Paulo stock exchange, our only sample exchange from the South American continent. Thus, it is not obvious that one could totally imply that the trading system costs provide the most significant impact even if data on prices of such inputs were available, which they are not. Individual stock exchanges are not generally able (or willing) to report their costs by activity. This makes it difficult to organise detailed statistical series on their cost structures. However, one reason for homogeneous system costs may be that the exchanges use fairly similar computer hardware and software, which are relatively more or less similarly priced internationally because the suppliers use same technology and consulting companies all over the world.

Table 1. **Distribution of average cost structure by region (percentages of total cost)**

	Systems cost	Adminis-tration cost	Employee cost	Office cost	Depreciation cost	Other cost
Asia	16.20	14.15	29.1	11.95	9.3	19.0
Europe	20.30	6.6	33.35	8.95	10.70	20.0
North America	21.7	10.60	38.10	4.55	8.55	16.45
South America	8.75	19.55	13.60	5.70	10.35	37.10

These averages are taken from FIBV reports. Information is based only on later years where detailed aggregate numbers are reported.

Indeed the labour cost varies across continents. Table 1 clearly shows higher proportion of expenses by exchanges in the U.S. (38.10 %) relative to other regions e.g. Asia-Pacific region (29.10 %). Unfortunately, disaggregated data on cross-country labour costs for stock exchanges are not available in most of the

Annual reports we have collected (Annual Reports 1989–1998) so far. In order to include at least one relevant input price variable, we introduce (Gross Domestic Product) GDP per capita as a proxy for differences of labour costs across countries. Alternatively, we were able to get the average wage rate data for countries representing 21 of the exchanges. We investigate the accuracy and consistency of the GDP per capita variable by estimating regressions using this alternative wage input variable for the sub-sample. First, we find that these two alternatives input variables are highly and significantly correlated (0.86) with each other. Importantly, the result of the sub-sample, using the wage data, did not reveal any significantly different outcome of coefficients, significance of the variables, and cost elasticities, relative to the ones reported in this paper based on GDP per capita variable.[14]

Some of the stock exchanges have expanded their operations to include derivatives and settlement business. Many of these stock exchanges do not publish sectoral cost figures. In order to incorporate such differences in reported cost data, we add a dummy variable in all regression estimations highlighting those exchanges whose business activities and cost data include derivatives and/or securities settlement expenses, in addition to the output and input variables.

5 Data and descriptive statistics

As discussed earlier, due to the lack and limitation of firm specific data on cost (or revenue) for exchange operations, there is hardly any direct empirical attempt to trace the possible existence for economies of scale in stock exchange operations. The data for this study were acquired by collecting annual reports requesting information from 45 stock exchanges, of which 38 provided uniform and consistent information (Appendix 1 and Annual Reports 1989–1998).[15] Although the information content of the reports varies, we were able to get the necessary information on operating costs and depreciation. For the cost measure, we have included all operative costs, depreciation & leases i.e., we excluded financial and extra ordinary items. We also let each exchange to comment on its calculated cost figures but took the final decisions by ourselves.

The exchanges also vary institutionally. Sixteen of these institutions are engaged 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. As mentioned earlier, these 38 stock exchanges represent 4 continents that include all major exchanges in the world. Data on output of exchanges were found in the International Federation of Stock Exchanges (FIBV) Annual Yearbooks (1989–1998). As stated, 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, we 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 e.g., by releasing news and monitoring whether companies

[14] These alternative estimates are available upon request.

[15] Fiscal year is not the same as the calendar year in every country. Therefore the cost data for some exchanges is e.g. for 1989 from 6/1989–6/1990.

follow the regulations set for the marketplace.[16] We approximate this output by using data on number and market value of listed companies. In total, we have 174 observations in our unbalanced panel data set.

The input variable, GDP per capita, is taken from the IFS (International Financial Statistics). As mentioned earlier, the accuracy of the GDP per capita variable will be controlled in a subset of the countries included in the study by employing wage data for 21 countries. The wage rate for the industry for the sub-sample countries was also taken from the IFS. All the data were collected in national currencies and converted into uniform measures in US dollars by using the average foreign exchange rates for the given year. This data is taken from the IFS as well.

The average output statistics (a table portraying output statistics of a representative sample year is shown in the Appendix 2) of the stock exchanges reveal that the NYSE posits as the largest market place, while NASDAQ presents almost twice as many listed companies as the NYSE and LSE. Value of share trading is highest on the NYSE followed by NASDAQ. The largest number of transactions was executed in the Taiwanese stock exchange. The table shows that both small and big exchanges can in principle be efficient because e.g. the NYSE, LSE, the Irish Stock Exchange and the Taiwan Stock Exchange all have very good performance figures.[17] 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 higher costs, but the figure is not comparable because it includes costs from the derivatives exchange).

A relative average cost comparison (Table 2) shows that the average per trade cost is $9.85 in Europe and $11.14 in North America relative to a high of $14.01 in Asia-Pacific markets. Cost as a ratio of the value of trade – reported in the second column – is not significantly different across regions except the averages are a bit higher among European exchanges. The cost per value of company reveals substantially lower cost ratio in European (0.32) and North American (0.33) exchanges relative to the ratios reported by the Asia-Pacific exchanges (0.43). The cost ratio per number of company is however higher for North American exchanges.

[16] 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.
[17] 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.

Table 2. **Average cost performance (ranges are in parenthesis)**

Regions	Cost/NTRADE	Cost/VTRADE	Cost/VCOM	Cost/NCOM
Asia-Pacific	14.01	0.68	0.43	93.61
	(0.98–55.68)	(0.17–0.81)	(0.13–1.21)	(16.81–266.17)
Europe	9.85	0.98	0.32	92.23
	(2.07–24.79)	(0.20–4.76)	(0.06–1.22)	(17.28–217.68)
North America	11.14	0.67	0.33	99.45
	(3.81–34.32)	(0.13–3.19)	(0.02–3.13)	(14.47–194.70)
South America	44.51	0.88	0.33	91.06
Combined	12.35	0.14	0.31	94.32

A graphical representation of the data – as shown in the appendix 3 – indicates that there are fairly pronounced symptoms of returns to scale in the value of trading (Figure 1) but little or no economies of scale for activities involving number of companies (Figure 2).

6 Empirical evidence

First, based solely on statistical considerations from the sample data, we select two variables that are the most relevant proxies for output. All potential output variables – the number (NTRADE) and value (VTRADE) of transactions and the number (NCOM) and total value (VCOM) of listed companies – as well as the binary variable (D)[18] are regressed on total cost (C) variable. The model was in logarithmic form. Overall, the evidence clearly shows (see appendix 4) that NCOM and VTRADE variables have the highest coefficient of determination than any other combination of the explanatory variables and thus were selected. [19] GNP per capita (GNPC) was used as a proxy for overall country cost levels in the analysis. [20,21] The translog model given by equation (4.1) is thus estimated as

$$\begin{aligned} \ln C = {} & \ln\alpha_0 + \alpha_1 \ln Q_1 \alpha_2 \ln Q_2 + \gamma_{11}(\ln Q_1)^2 + \gamma_{22}(\ln Q_2)^2 \\ & + \beta_1 \ln P_1 + \gamma_{11}(\ln P_1)^2 + \gamma_{12} \ln Q_1 \ln Q_2 + \sum_j \gamma_{ij} P_1 \ln Q_j + D, \end{aligned} \tag{6.1}$$

[18] 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.

[19] It can be argued that number of companies is 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 the empirical evidence in terms of explanatory power is clear.

[20] As we have discussed in earlier section of this paper that direct price information on the inputs was not available since most stock exchanges do not publish such information. Even the International Federation of stock Exchanges acknowledges this point FIBV (1997).

[21] Reported earlier also the fact that the relative accuracy of the GNBC variable was tested in asubset of the countries included in the study. Wage for industry was available for 21 countries most of the countries beeing OECD countries. Estimation results were practically unchanged.

The outcome of the estimation of this equation on the combined data and on different sub-samples of the data, representing different regions of the world is, presented in on Table 3. These regions are based on exchanges located in North America, Europe, and Asia-Pacific markets. The results are quite similar across different estimates.

Table 3. **Translog estimations (1989–1998)**

Variables	Combined data	North America	Europe	Asia-Pacific
Intercept	1.252	10.24	25.232	8.072
	(0.197)	(7.22)*	(1.95)*	(0.88)
VTRADE	1.442	12.99	1.068	0.429
	(2.12)*	(5.47)*	(0.87)	(0.45)
$(VTRADE)^2$	0.0140	–0.006	0.023	0.001
	(0.88)	(0.37)	(1.05)	(0.02)
NCOM	–2.896	–9.616	–0.167	2.627
	(2.34)*	(1.91)	(0.05)	(1.05)
$(NCOM)^2$	–0.026	–0.282	0.118	0.226
	(0.35)	(4.54)*	(0.78)	(0.83)
GNPC	–0.251	–2.224	–5.89	–3.430
	(0.28)	(7.49)*	(2.25)*	(2.91)*
$(GNPC)^2$	0.051	1.176	0.410	–0.071
	(1.05)	(7.38)*	(2.38)*	(0.56)
VTRADE*NCOM	–0.006	–0.086	–0.049	–0.329
	(0.11)	(1.18)	(0.38)	(2.54)*
NCOM*GNPC	0.366	1.571	0.312	0.134
	(3.24)*	(2.83)*	(0.09)	(0.59)
VTRADE*GNPC	–0.158	–1.18	–0.133	0.218
	(2.69)*	(4.43)*	(1.04)	(2.34)*
D	0.234	–0.69	0.423	0.173
	(2.59)*	(3.05)*	(3.53)*	(1.16)
Adjusted R^2	0.8800	0.9945	0.9317	0.9356
F-Statistics	127.92*	675.76*	106.04	75.13*
No. of observations	172	38	80	54

* Significant at least at the 5 per cent significance level.

In most cases, the output and input variables as well as the binary variables turned out to be statistically significant. But importantly for such translog estimates, the model statistics revealed strong adjusted R-squared and F-statistics exonerating the choice of output and input variables included in this study. A number of interesting observations stand out in the table. First, the evidence indicates that processing higher number of company reduces cost for exchanges in the North American and developed market regions. On the contrary, in the Asian-Pacific and to some extent in the less developed market regions, the same processing cause higher cost. This reveals the possible inability of these exchanges to control cost associated with processing of additional companies. Second, the cross term variable is negative in all estimates and statistically significant in Asia-Pacific sub-samples indicating synergies among the two outputs in exchanges especially in the later regions. The dummy variable is statistically significant in most estimates with a wide range of coefficient size and sign (–0.69 in the North American sub-sample and +0.17 in the Asia-Pacific estimates). This may be interpreted that costs are lower in some markets as they expand to derivative and settlement activities along with the traditional security exchange business where as the experience is totally opposite in some other markets. This figure is somewhat higher than one might expect from looking at annual reports of derivative exchanges and securities settlement entities.

Additionally, we also estimate a series of similar regressions using simple linear models that include or exclude the proxy for input (GNPC) variable in the regressions. These estimates perform quite well according to the model specification statistics.[22] A sample of some of these estimates is shown in appendix 5.

We estimate scale elasticity at the sample median as well at the mean. All results are reasonably similar in most estimates. We prefer the median estimates because when we rank the listed variables by the number of the listed companies, we find that the sample is skewed, as there are few very big stock exchanges with a large number of companies listed (see appendix 2). Therefore, we opt for median estimate as more represntative over the mean estimates. These estimates are obtained by differentiating the estimated translog model and calculating the elasticity by applying the estimated coefficients from Table 3 (reported in panel A). We compute Ray average cost (Baumol et al. (1988)), starting as usual by estimating a loglinear expansion path for the stock exchanges, lnVTRADE = f (lnNCOM) on the sample data. We repeat our estimates on sub-samples. 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. The scale elasticity with respect to each output and the Ray average cost (S) is reported in Table 4, panel A. The inverse of S is the scale elasticity of the combination of the two outputs.

[22] The linear model was re-estimated on the data by weighted least squares using the market capitalization (VCOM) as a weighting variable. The coefficients do not change much but the coefficient of determination is as high as 99 %, i.e. this very simple linear model is able to explain almost all the variation in the costs of exchanges around the world. This provides some evidence that the results are not dominated by the large number of small stock exchanges in the estimations. For a few variables, the magnitude and significance of coefficients in these estimates are not consistent with same estimates using translog functional form.

Table 4. **Estimated Ray average cost[1] and multiproduct scale economies in translog and loglinear models 1989–1998[2]**

Panel A: Elasticity based on estimates that include both output and input variables

Region	e^{c}_{COM} [3]	e^{c}_{VTRADE} [4]	e^{c}_{RAY} [5]	S^{6}
North American	0.178	0.306	0.485	2.063
Europe	0.608	0.288	0.895	1.117
Asia	0.859	0.548	1.407	0.711
Median	**0.545**	**0.409**	**0.954**	**1.048**
10 Largest	0.234	0.217	0.451	2.220
10 Smallest	0.603	0.348	0.951	1.052
Loglinear model Median	**0.547**	**0.408**	**0.955**	**1.048**

Panel B: Elasticity based on estimates that include only output variables

Region	e^{c}_{COM} [3]	e^{c}_{VTRADE} [4]	e^{c}_{RAY} [5]	S^{6}
North American	0.201	0.343	0.544	1.838
Europe	0.495	0.257	0.752	1.329
Asia	0.803	0.451	1.254	0.797
Median	**0.483**	**0.426**	**0.909**	**1.100**
10 Largest	0.276	0.389	0.665	1.505
10 Smallest	0.488	0.404	0.893	1.120
Loglinear model Median	**0.501**	**0.362**	**0.863**	**1.158**

[1] Based on median number of companies in each group.
[2] Estimated expansion path for stock exchanges, lnVTRADE = 9.240 + 1.48 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 median scale elasticity coefficient of the combined sample is 0.409 with respect to the value of trading i.e. almost 41 % increase in case the value of transactions is doubled. This means that there are significant scale economies involved in trading operations. On the other hand, the elasticity coefficient is 0.545 with respect to the number of company i.e. an increase in costs by 55 % if the number of company is doubled. This means overall economies of scale also exist in activities related to the processing of firm-specific information however at a relatively lesser extent to processing trades. This is reasonable since the listing procedures and communication with the listed companies require more labour intensive efforts relative to standardized technology intensive order processing. Evidence here suggests that doubling both outputs does not pay off because the implied increase in costs is 95 %, which is fairly close to constant costs. Comparison of the results with the outcome of the estimated log linear model reveals strikingly similar estimates. For brevity, we only report the median estimates of the combined sample for the log linear estimations.

Analysing the data by regions, we notice the existence of high economies of scale in the North American and European sub-sample. In the American exchanges, the cost of doubling even both outputs increase cost by only 49 %. The cost of processing firm-specific information is astronomically cheaper than similar expenses in other region of the world. It will cost only an additional 18 % to process twice the existing number of companies. In the European sub-sample, we notice the comparative advantage is more (29 % additional cost for doubling output) with respect to value of transactions although strong economies of scale also exist in the number of company category (61 % additional cost). However, the experiences in Asia-Pacific exchanges reveal a different picture. Indeed, the exchanges in these regions do enjoy some economies of scale in respect of increasing transactions, however, they suffer from substantially higher cost relative to other regions in processing additional companies. The cost will increase by 86 % if the number of companies double.[23] It is not cost effective in doubling both outputs by these exchanges as we see the emergence of diseconomies of scale with cost rising to 141 % for doubling both outputs.

In order to gain further understanding of cost elasticity, we estimate sub-samples of 10 largest and 10 smallest exchanges based on market value of companies (see appendix 2). The rows of these group in panel A represent that a substantial economies of scale exists for the largest 10 exchanges for both listing additional companies and processing of trades. The cost of processing twice the number of existing number of companies and trade processing is an additional 13 % and 32 % respectively. Economies of scale also exist among the 10 smallest exchanges, however, the significant amount of cost savings is related to processing of trades. For the smallest 10 exchanges, doubling the trade processing increases cost by 35 % compared to an increase of cost by 60 % for doubling the number of companies listed. The doubling of both outputs is not cost effective for small exchanges as the implied cost increases by 95 %.

This may suggest that mergers and/or alliances of largest exchanges may be worthwhile as it is more efficient to expand relative to the smallest ones.[24] This is somewhat consistent with the findings of Malkamäki (1999) where the institutions in the top quartile were found to be in more of a cost advantageous position relative to the firms in the smallest quartiles in the 1997 cross-sectional year. Our results also indicate that it might be optimal for the smallest exchanges to form implicit mergers with each other i.e. centralize their trading function but keep the rest separated. Lack of data in the early years did not give us an opportunity to further disaggregate the data by different size groups in different sub-samples years. However, we repeated additional estimates where input prices and an index of technology are assumed to be embedded in the constant term.[25] These estimates are reported in Panel B of Table 4. In all cases, the elasticity estimates are similar

[23] Given we have only one exchange from South America in our sample, we have included that exchange (Sao Paulo) with the Asian-Pacific sub-sample. Even excluding this exchange from this region provided similar cost elasticities.

[24] It can be also argued that aggregation of trading venues may encourage monopoly behavior reluctant to change and slow to adopt new technology. However, network externalities create opportunities that are not only achieving production-side economies of scale but demand-side economies of scale (Shapiro and Varian (1999)). Economides (1993) believes that network (e.g. electronic trading systems) exhibit positive critical mass in some market structure achieving optimality and higher welfare than feasible under perfect competition.

[25] Thus homogeneity, concavity, and nonnegativity cannot be explicitly imposed. Also, factor demand equations via Shepard's Lemma cannot be used in the estimation.

or consistent with reported results based on Panel A where elasticity is computed from regressions that include explicit input prices. Given that these later estimates broadly maintain all previous conclusions, we limit our explanations of the specific results.

The overall economies of scope (OEOS) are presented in Table 5. The degree of OEOS is simply the percentage increase in total costs from specialised activities. Overall, we find strong evidence of scope economies in the combined data where there is at least 50 % (range 51 %–68 %) or more cost savings by concentrating on both trade processing and listing additional companies irrespective of the functional form used. Like in the case of economies of scale, the North American exchanges enjoy the highest economies of scope where on average costs would be almost more than double (range 0,97–1,37) in all cases by making the firm to concentrate in only one-output activities. For Europe, the cost savings from joint concentration of activities are 59 %, 61%, and 41 % in the translog, loglinear and quadratic model estimates respectively. For the Asian sub-sample, there is a slight diseconomies of scope as evidenced by 15 % in the translog model. However, the loglinear and quadratic models report small economies of scope. Focusing on the largest 10 exchanges, we find significant economies of scope where there is a saving of 70 %, 64 % and 89 % respectively by focusing on both activities over concentrating on one. However, for the smallest 10 exchanges such cost saving is negligible with 4 % in translog and 3 % in loglinear estimates. In fact, in the quadratic model, there is a small but insignificant diseconomies of scope reporting 10 % increase in cost from joint concentration in both activities.

Table 5. **Economies of scope 1989–1998**

Region[1]	Overall Economies of Scope[2]		
	Translog Model	Loglinear Model	Quadratic Model
North American	0,97	1,08	1,37
	(3,72)*[3]	(4,06)*	(2,98)*
Europe	0,59	0,61	0,41
	(2,26)*	(2,07)*	(2,52)*
Asia	–0,15	0,06	0,13
	(0,52)	(0,93)	(1,06)
Combined Sample	**0,54**	**0,51**	**0,68**
	(2,91)*	**(3,06)***	**(3,54)***
10 Largest	0,70	0,64	0,89
	(2,63)*	(2,09)*	(2,84)*
10 Smallest	0,04	0,03	-0,10
	(0,22)	(0,30)	(0,48)

[1] Economies of scope evaluated at the median of each group.
[2] Percentage increase in total cost from specialization production.
[3] t-statistics in parenthesis.
* means significantly different from zero at least 5 per cent significance levels.

Thus both overall economies of scale and scope seem to exist in North America and for the largest firms and disappear a bit for Asia and the smallest exchanges. The difference between North America and Asia may be due to the fact that Asian

Exchanges are typically small compared with North America. On the other hand, we argue that regulation regarding the North American exchanges and securities markets is more homogenous than the corresponding ones in Europe and Asia that shows least progress in continentalwise harmonisation of regulation, see e.g. (Freedman (1999)).

7 Conclusions

This study employs 1989–1998 experiences of 38 stock exchanges in 32 countries in four continents. The key intention of this paper is to inquire whether there is any cost saving from expanding the stock exchange businesses with special perspectives and insight given into the experience of exchanges by regions of the world and by size of the exchanges. The paper investigates the existence of economies of scale among exchanges using a translog cost function as well as linear logarithmic models. The paper uses outputs that proxy for processing trades and processing company specific information. The first function is more technical in nature requires skilled personnel, computers, and software in order to have appropriate matching and processing trading activities. The second function involves the rest i.e. 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.

Overall in the combined data, the result shows that activities related to both trading and firm-specific information processing possess economies of scale separately. Disaggregated results indicate that the exchanges in North American and European exchanges report substantially higher economies of scale relative to the exchanges in the Asia-Pacific regions. Moreover it portrays that there is an increasing trend of the largest exchanges gaining the most cost effectiveness. Results are somewhat similar in the evidence on overall economies of scope investigated using different cost functions.

The result supports the formation of mergers and alliances among the biggest exchanges. It clearly encourages the increasing of standardisation and scale. The overall scale elasticity however says that in case of small and medium size exchanges all self evident pooling of activities may not be cost saving. Therefore implicit mergers that seek to utilize returns to scale specifically in their trading systems may be a good way to handle the two functions simultaneously.

Our findings also suggest that regulation matters a lot for the efficiency of operative infrastructure companies in securities markets. We find returns to scale most in North America. Regulation regarding the North American exchanges and securities markets is more homogenous than the corresponding ones in Europe and Asia that shows least progress in continentalwise harmonisation of regulation. Therefore, it may be rational to leave operations that are subject to unharmonized national regulation i.e. the listing process, as well as other connections with companies, and news releases to the national stock exchanges. To what extent this represents a sustainable solution regarding the most traded listed companies in small national markets is questionable as the trading of securities globalise rapidly.

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Appendix 1

Stock exchanges included in the panel data

	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Amex				X	X	X	X	X	X	
Chicago							X	X	X	
Montreal	X	X	X	X	X	X	X	X	X	X
Nasdaq								X	X	
NYSE				X	X	X	X	X	X	
Toronto	X	X	X	X	X	X	X	X	X	X
Vancouver									X	
Sao Paulo				X	X	X	X	X	X	
Amsterdam	X	X	X	X	X	X	X	X	X	
Athens									X	X
Brussels				X	X	X	X	X	X	X
Budapest									X	
Copenhagen				X	X	X	X	X	X	X
Tallinn									X	X
Germany					X	X	X	X	X	X
Helsinki				X	X	X	X	X	X	X
Irish								X	X	
Istanbul							X	X	X	
Ljubljana					X	X	X		X	X
London				X	X	X	X	X	X	X
Luxembourg								X	X	
Madrid								X	X	
Oslo	X	X	X	X	X	X	X	X	X	X
Paris								X	X	
Prague									X	
Stockholm				X	X	X	X	X	X	
Switzerland							X	X	X	
Warsaw							X	X	X	
Australian					X	X	X	X	X	
Hong Kong		X	X	X	X	X	X	X	X	x
Jakarta					X	X	X	X	X	
Tokyo								X	X	
Kuala Lumpur					X	X	X	X	X	x
New Zealand	X	X	X		X	X	X	X	X	x
Osaka					X	X	X	X	X	
Philippine									X	
Taiwan					X	X	X	X	X	
Thailand								X	X	

Appendix 2

Representative output statistics for individual stock exchanges

	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
Chicago*	198325	10011.9	2142753	268
Montreal*	44715	1934.6	422694	557
NASDAQ	4481682	98960.4	1737510	5487
NYSE	5777602	102550.4	8879631	2626
Toronto*	305626	11142.2	567635	1420
Vancouver**	6479	2081.2	6615	1429
South America				
Sao Paulo**	191505	1871.0	255478	537
Europe, Africa, Middle East				
Amsterdam**	281248	3798.6	468897	348
Athens	21248	3733.3	33784	210
Brussels**	34055	2300.0	138938	265
Budapest*	7039		14700	49
Copenhagen	46886	1018.9	93766	249
Tallinn	1573	122.4	1139	28
Germany*	1072935	27815.5	825233	2696
Helsinki	36428	568.1	73322	126
Irish	17470	261.3	49371	102
Istanbul	59584	20552.0	61095	259
Ljubljana	548	131.4	1876	78
London	1925809	9673.4	1996225	2513
Luxembourg	1052	47.0	33892	284
Madrid	139229	7891.8	290383	388
Oslo	48176	829.8	66503	217
Paris	415818	37000.0	676311	924
Prague	7770		10817	91
Stockholm	176356	4836.0	264711	261
Switzerland*	569510	6130.0	575339	428
Warsaw	7981	3500.0	12135	143
Asia, Pacific				
Australian*	156271	6141.0	295411	1219
Hong Kong*	453900	32601.0	413323	658
Jakarta**	41378	2972.5	29050	281
Tokyo*	898579		2160585	1865
Kuala Lumbur	164482	21580.0	93182	703
New Zealand	9720	517.1	29889	190
Osaka	223803	1834.0		1275
Philippine**	19890	1850.0	31212	221
Taiwan	1254543	154345.0	296808	404
Thailand**	25259	8730.0	22792	431

* Costs include costs from derivative exchange activities in addition to the costs from stock exchange activities.

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

Appendix 3

Figure 1. **Costs and number of listed companies 1989–1998**

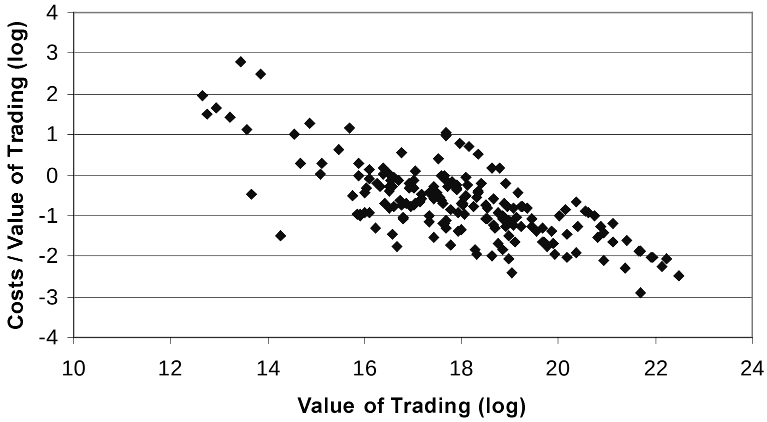
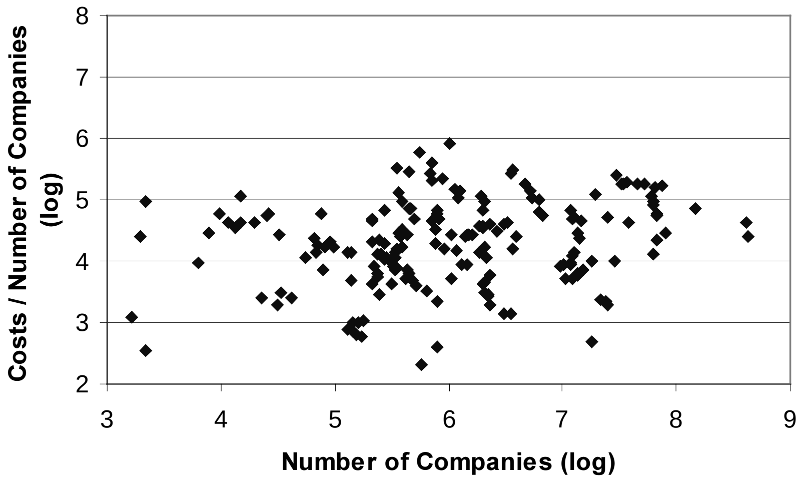


Figure 2. **Costs and scale of stock exchanges 1989–1998**



Appendix 4

Cost regressed on output proxies

	1	2	3	4
Intercept	–0.377	–1.802	–0.088	2.445
	(0.35)	(1.09)	(0.06)	(3.80)
NTRADE	–	–	0.396	0.314
			(2.99)	(2.98)
VTRADE	0.360	0.522	–	–
	(3.90)	(1.70)		
NCOM	0.680	–	–	0.864
	(4.21)			(5.16)
VCOM	–	0.134	0.374	–
		(0.41)	(3.27)	
D	0.188	0.321	0.351	0.179
	(1.14)	(1.14)	(1.28)	(0.77)
R^2	0.903	0.813	0.822	0.866
χ^2	0.103	0.884	0.911	0.626
N[a]	172	172	172	172

Appendix 5

Linear logarithmic estimations (1989–1998)

Variables	Combined data	North America	Europe	Asia Pacific
Intercept	–0,582	–31,450	0,079	–3,580
	(1,15)	(8,14)*	(0,03)	(5,44)*
VTRADE	0,421	0,258	0,21	0,567
	(13,46)*	(4,07)*	(4,04)*	(12,87)*
NCOM	0,553	0,766	0,012	0,790
	(1,97)*	(1,67)	(9,66)*	(1,45)
GNPC	–0,007	3,182	0,121	0,129
	(0,17)	(8,66)*	(0,52)	(2,35)*
D	0,161	–0,527	0,231	0,020
	(2,11)*	(1,89)	(1,50)	(2,19)*
Adjusted R^2	0,8722	0,9350	0,9031	0,9161
F-Statistics	296,12*	134,15*	288,14*	140,20*
Number of observastion	172	38	80	54

* Significant at least at the 5 per cent significance level.

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