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Do networks in the stock exchange industry pay off? European evidence

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Do networks in the stock exchange industry pay off? European evidence

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Do networks in the stock exchange industry pay off? European evidence

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Abstract

The economic theory of network externalities provides the rationale for this paper, which investigates whether adoption of network strategies in European stock exchanges creates additional value in the provision of trading services. Using unbalanced panel data from all major European exchanges over the period 1996–2000, the paper examines empirically the presence of network effects on the liquidity, growth, and efficiency of the exchanges; the transaction cost of trades; and the cost of exchange operations. The evidence shows that adopting a network strategy is significantly associated with higher liquidity, growth and efficiency in the sample markets. Moreover, a network strategy helps to reduce transaction costs of trades as well as operational costs for stock exchanges.

Key words: stock exchanges, network externalities, remote access, Europe

JEL classification numbers: F36, G15, O52

Kannattaako pörssien verkostoituminen? Eurooppalaisia tuloksia

Suomen Pankin keskustelualoitteita 2/2003

Iftekhar Hasan – Heiko Schmiedel
Tutkimusosasto

Tiivistelmä

Tutkimuksessa tarkastellaan verkostoitumisen vaikutuksia koskevan teorian perusteella, tuottaako Euroopan pörssien verkostoituminen lisäarvoa kaupankäyntipalvelujen tuotannossa. Euroopan tärkeimmät pörssit kattavan paneeliaineiston avulla työssä tutkitaan verkostoitumisen vaikutuksia markkinapaikkojen likvidiyteen, kasvuun ja tehokkuuteen, kaupanteon kustannuksiin ja pörssien toimintakuluihin. Tulosten mukaan verkostoitumisstrategian valinneet pörssit ovat muita merkitsevästi likvidimpiä, tehokkaampia ja nopeammin kasvavia. Lisäksi verkostoituminen auttaa pienentämään kaupankäyntikustannuksia ja pörssien toimintakuluja.

Avainsanat: pörssit, verkostovaikutukset, etäosallistuminen, Eurooppa

JEL-luokittelu: F36, G15, O52

Contents

1 Introduction

In recent years, stock exchanges have been experiencing a challenging and unprecedented environment. Globalization and integration of all types of financial markets, the continuous emergence of innovative technology, new deregulatory initiatives, and the adoption of alternative corporate governance systems are among some of the key issues faced by exchanges around the world. The integration phenomenon increased the popularity of mergers, especially implicit mergers or network deals among exchanges. As companies seek to broaden their shareholder base and raise capital beyond local markets (Domowitz, Glen, Madhavan (1998), Pagano, Randl, Roell, and Zechner (2001), such implicit mergers[1] are preferred by investors as an alternative to multiple listings across markets and exchanges prefer this type of deal, which allows them to avoid direct competition from stronger markets and the fragmentation of liquidity. This type of arrangement is likely to develop a competitive environment, where the most efficient exchanges will eventually win the confidence of investors, traders and companies (Cybo-Ottone, Di Noia and Murgia 2000).

The emergence of these types of consolidation provides a common trading platform among exchanges who are willing to open up to each others' markets for cross listing and trading purposes with ample freedom for brokers and traders to operate across markets. Network arrangements will help in gaining new demand for exchange products and are also likely to bring efficiency gains through economies of scale (Economides 1995, Hasan and Malkamäki 2001). Hagel III-Armstrong (1997), and Saloner and Shepard (1995) emphasize the role of critical mass and time dimensions in evaluating the true impact of network scope.

Shapiro and Varian (1999) point out that computer technology, ie networks, will dominate the trading business. Networks will provide investors with options to choose from alternative preferences. The recent success of EUREX is a good example of how networks can replace a trading floor in another country.[2] European exchanges, historically local monopolies, are the most active players in adopting such a network or common trading platform. Taking their cue from NASDAQ's proposed and partially implemented global plan to list and trade across markets, the European exchanges have taken the lead in forming and joining in active network cooperation among European markets. In fact, the

[1] A definition also used by Di Noia (2001) and Domowitz (1995) for equity and derivative markets respectively.

[2] An additional example is the emergence of network externalities especially in the United States, where there has been a huge invasion of new equity routing/matching/trading systems, eg, Instinet, POSIT, AZ, and Attain etc. These systems have gained increasing volume, especially in stocks listed on NASDAQ as well as many NYSE-listed stocks. This situation has opened increased pressure and possibilities for exchanges to cooperate and compete for market share.

majority of the 100 executed or potential merger-related deals in the world are in Europe (Cybo-Ottone et al 2000). Today, there are four inter-exchange cooperation models that link security markets within and outside European boundaries (Figure 1).

While the finance literature is abundant in introducing and describing the potential benefits of network arrangements in terms of increased participation, liquidity, efficiency, and transaction costs, no article discusses the potential consequences or impact of adopting such network cooperation. Cybo-Ottone et al (2000) provide the first descriptive approach to understanding mergers and cooperation across exchanges; however, their study was focused primarily on the factors associated with consolidation efforts. A separate volume of papers focused on the motives as well as on the consequences of cross-border listings and cross-listed stocks (Blass and Yafeh 2001, Chaplinsky and Ramchand 2000,Foerster and Karolyi 1998,Karolyi 1998,and Pagano, Röell and Zechner 2002). These papers, however, are more focused on the motivations and consequences among the companies rather than on the impact of cross listings on markets. Importantly, for our purpose, none of the papers deals with issues associated with networks or implicit mergers.

In this paper, we attempt to fill this gap in the literature not only by introducing details on the landscape of network cooperation among exchanges in Europe, but also by showing the potential impact of such inter-exchange cooperative initiatives on the performance, growth, and turnover of the sample exchanges. Additionally, we present evidence on the consequences of adopting such network cooperation for the cost of trading, investors, and for the cost of operations to the stock exchanges.[3] Our evidence shows that even after controlling for pertinent variables, the network cooperation decision, represented by several alternative network proxy variables, is significantly associated with stock exchange market capitalisation, its growth, as well as its efficiency. Moreover, network strategy apparently helps markets in lowering transaction costs of trades as well as operational costs for stock exchanges.

The paper is organised as follows: Section 2 introduces networks, alliances, and cooperation among European stock exchanges followed by a brief literature review in Section 3. Section 4 introduces the data and descriptive statistics. Section 5 reports the results and the conclusions are presented in Section 6.

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[3] Arnold, Hersch, Mulherin, and Netter (1999), Domowitz and Steil (1999), and Pirrong (1999) stress the importance of assuming that exchanges are actually operative firms and argue that the industrial structure of market places cannot 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, ie the traders. It is equally important to know more about the provision of alternative technologies for trading services.

2 Networks, alliances, and cooperation among European stock exchanges

Evidence for the presence of network externalities is starting to develop in various ways and can be seen in types of international alliances and cooperative arrangements between exchanges, although not all announced initiatives and attempts to foster cross-border links among stock exchanges have been completed. The overall goal is to provide investors the opportunity to trade shares of globally listed firms on a continuous 24/7 basis at the lowest possible cost of trading. In this scenario, the implications of electronic trading play a pivotal role and are far-reaching for the entire securities industry. However, in financial exchange markets, the innovation and implementation of new electronic trading technologies varies considerably by geography, culture, and the organizational structure of the exchanges, which have been undergoing enormous transitions in recent years (Hasan, Malkamäki, and Schmiedel 2002). For example, there is evidence that North American stock exchanges operate most efficiently in order to serve the best interests of the marketplace, and in particular those of investors. However, Europe has been much quicker and ambitious to respond to the rise of electronic trading by adopting it and creating several cooperative market linkages between stock and derivative exchanges (Schmiedel 2001 and 2002).

Amongst the anticipated benefits of cooperative projects and strategic alliances among exchanges were that they would give exchanges the opportunity to gain advantage over their competitors, mostly by extending trading hours, allowing for remote membership, modifying prices, and thereby lowering costs. It is crucial for the success of networked electronic trading platforms that increasing efficiency, transparency, faster executions, and lowering costs can attract a critical mass of order-flows and generate additional liquidity to the market. The liquidity effect, in turn, is determined by the scope and size of the network requiring compatible trading technologies.

A range of the most recent market linkages and cooperative initiatives proposed and undertaken by various stock exchanges deserves particular attention in this section. The analysis of inter-exchange connection schemes focuses on European projects as well as on US and other global order-routing linkages. A good survey of historical deals among stock exchanges illustrating various aspects of cooperation is presented in a number of studies, including the work of Cybo-Ottone, Di Noia, and Murgia (2000), Domowitz (1995), Domowitz and Steil (1999), Lee (1998), and Licht (1998).

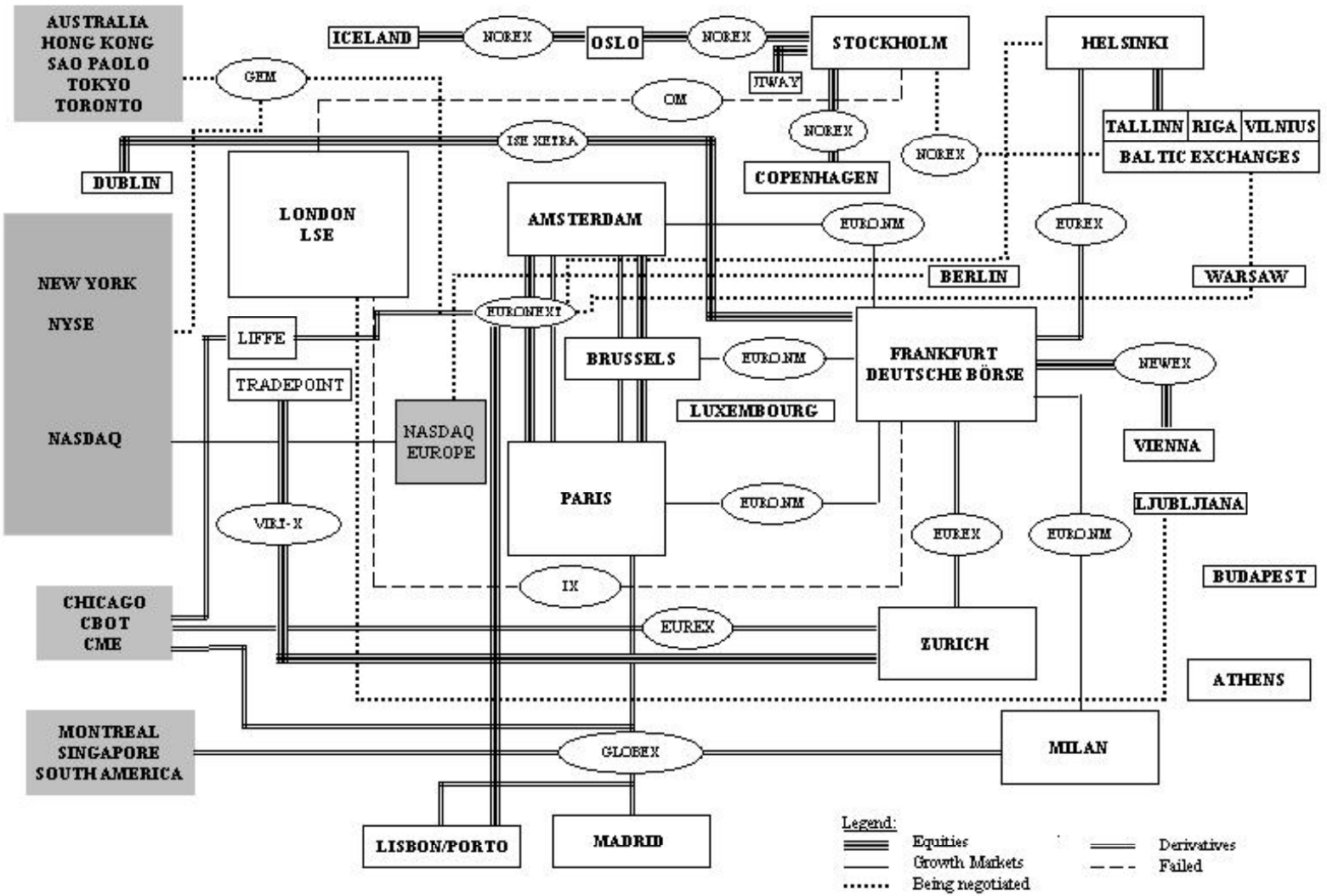
Figure 1 illustrates the architecture of market linkages and cooperation proposed and undertaken by various stock and derivative exchanges, forming a complex and networked European securities trading landscape. Tracing back the development of these linkages, it can be observed that a large number of deals

among exchanges were only quite recent phenomena, which have been mostly negotiated between 1997–2002. It seems evident that financial exchanges use different means of coping with investor demands for lower trading costs, improved liquidity and immediate access to international trading. However, some structural patterns can be derived as to how European stock exchanges create inter-connections between cooperating exchanges. Consistent with a recent OECD study (2001), four different models of inter-exchange co-operation can be identified in figure 1.

The first strategy has been promoted by NASDAQ. The basic idea is to establish branches with local partners using a common technology in order to have access to regional markets while retaining regional commercial and regulatory characteristics. Prominent examples are NASDAQ Europe, NASDAQ Canada, and NASDAQ Japan. NASDAQ Europe, a re-launch of Easdaq, has established the European hub of a global market and has created a basis for further integration with other national and regional European markets. However, it seems crucial for the successful realization of NASDAQ's global strategy to establish a robust trading and listing presence, thereby building up inter-connected trading hubs for a world-wide electronic marketplace.

Rival interest in setting up a European-based network of growth company markets has been expressed by EURO.NM. In the wave of the founding of new markets on a national basis, the Paris Bourse and the Belgian Bourse de Bruxelles initiated the creation a similar European-wide networked market to facilitate and encourage cross-border cooperation. Since 1999, five new market exchanges have belonged to the European network of high growth and young companies, which includes Neuer Markt (Germany), Nouveau Marché (France), Nieuwe Markt (The Netherlands), and the Nuovo Mercato (Italy). Among other objectives regarding common international marketing and promotional activities, EURO.NM attempts to harmonize market rules in respect of listing and disclosure requirements as well as trading procedures. It further seeks to establish connections between markets in order to simplify joint trading and common data dissemination. It is also intended that EURO.NM represent an institutionalised body in order to articulate the shared and common interests of its members to European authorities and other non-European entities. Concerning its future prospects, it remains to be seen if EURO.NM or its members can successfully pursue such a concept and were able to differentiate themselves from other potential competitors, eg NASDAQ Europe.

Figure 1.


AUSTRALIA
HONG KONG
SAO PAOLO
TOKYO
TORONTO
GEM
ICELAND
NOREX
OSLO
NOREX
STOCKHOLM
HELSINKI
JIWAY
OM
TALLINN
RIGA
VILNIUS
BALTIC EXCHANGES
ISE XETRA
NOREX
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DUBLIN
COPENHAGEN
LONDON
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DEUTSCHE BÖRSE
NEWEX
TRADEPOINT
LUXEMBOURG
NASDAQ
NASDAQ
EUROPE
VIENNA
PARIS
EURONM
LJUBLJIANA
VIRT-X
EUREX
EURONM
BUDAPEST
IX
CHICAGO
CBOT
CME
EUREX
ZURICH
ATHENS
MONTREAL
SINGAPORE
SOUTH AMERICA
GLOBEX
MILAN
LISBON/PORTO
MADRID
Legend:
Equities
Growth Markets
Being negotiated
Derivatives
Failed

Similarly, other trading service providers launched common efforts to create a pan-European market. As of June 2001, Virt-x, a collaboration of the SWX Swiss Exchange and the UK Tradepoint Financial Networks plc, started trading all major pan-European blue-chip equities that are included in major indices. It is stated by its founders that Virt-x was designed in order to respond to the market demand for an efficient and cost-effective pan-European blue chip exchange created to support increasing cross-border trading in European blue chips. The virt-x market is based on an integrated trading, clearing and settlement model aimed at facilitating the process of trading and significantly reducing the costs associated with cross-border trading. A crucial question for the success of virt-x is whether it can benefit from first mover advantage in developing critical mass in the rapidly expanding cross-border European securities markets.

A second type includes mergers among exchanges. In legal terms, an explicit merger is defined as a transaction that leads to the creation of a new entity incorporating the two or more merging entities (Lee 1998). Here the purpose is to achieve actively economies of scale by concentrating trading on one stock exchange with a common trading system. Examples of such initiatives include the recent merger of the Paris, Brussels, and Amsterdam exchanges under the name Euronext N.V. in September 2000, thus becoming the first pan-European exchange, or the ill-fated London Stock Exchange and Deutsche Börse merger attempt. As of the end of 2001, 1539 firms were listed on Euronext regulated markets representing a market capitalisation of almost USD 2 trillion US$.

Only recently, other European exchanges joined or signed cross-membership and cross-access agreements with Euronext N.V. on cash and derivative trading. In February 2002, the Portuguese exchange, BVLP – Bolsa de Valores de Lisboa e Porto, formed through the restructuring of the former Lisbon Stock Exchange Association and the Porto Derivative Exchange Association, joined Euronext after all its shareholders unanimously accepted Euronext's merger offer. Following the merger, BVLP shareholders became shareholders of Euronext N.V. and BVLP. This wholly owned subsidiary of Euronext N.V. has been renamed Euronext Lisbon in a similar way to Euronext Paris, Euronext Amsterdam and Euronext Brussels. As a result of the merger, Euronext aims to offer improved services to investors, intermediaries and issuers, gain access to an additional market and distribution network, increase its scale, extend the use of its trading and clearing systems, as well as to reinforce its position in the European exchange sector. In particular, Euronext's unified cash trading platform, NSC, and its market model, both already implemented in France, Belgium, and in the Netherlands in the course of 2001, is also intended to be implemented in Portugal, ensuring Euronext members equal access to all financial instruments traded on these markets. Excluding ownership arrangements, both the Helsinki Stock Exchange (HEX) and the Warsaw Stock Exchange (WSE) agreed on cross-membership and cross-trading with Euronext N.V. While the cross-membership agreement is designed to

develop exchange member trading activities, the cross-access agreement provides the technical solutions for these members to trade from their actual locations on HEX, WSE and Euronext cash markets. At a technical level, HEX and WSE members are intended to have access to the trading of all Euronext cash products via the unified access architecture of NSC through remote membership links. HEX will establish an access point in Euronext, which offers cost effective access for Euronext members to the Finnish securities market. The technical implementation is scheduled to be completed by the end of 2002 and in 2004 for the HEX and the WSE respectively. Already in 1992 the WSE and the Paris exchange established a close relationship, as the Paris exchange accompanied WSE in the automation of its trading, which it adopted the French NSC trading system.

A third strategy is the attempted hostile take-over bid pursued by the Swedish-based OM Group for the London Stock Exchange. Similar to the iX merger, the OM bid finally failed in the autumn of 2000, mainly due to a mixture of regulatory uncertainty, technological nationalism, and skepticism among politicians and small shareholders of the London Stock Exchange. At the same time, another exchange concept, called Jiway, was launched initially as a joint venture of the OM Group and Morgan Stanley Dean Witter, who had a 60/40% share respectively. Changing the capital structure effective as of October 2001, OM became the sole owner of the Jiway exchange. Jiway is Europe's first integrated stock exchange for retail investors. Private investors are allowed to directly connect to the Jiway electronic trading platform and to have access to more than 6,000 U.S. and European shares.

Finally, a fourth design of exchange cooperation is portrayed by the New York Stock Exchange. This attempt seeks to interconnect leading equity exchanges in a Global Equity Market (GEM) by means of a common electronic interface. The GEM project is chaired by the New York Stock Exchange and the participant exchanges comprise the Australian Stock Exchange, Euronext, the Hong Kong Exchanges and Clearing, the Bolsa Mexicana de Valores, the Bolsa de Valores de Sao Paulo, the Tokyo Stock Exchange, and the Toronto Stock Exchange. Its stated aim is to provide its customers with a transparent 24/7 trading mechanism for the world's blue chip equities, thereby improving global liquidity and achieving better global price discovery. Transactions on the GEM should be channelled through the respective local stock exchange while creating a single global pool of liquidity.

Similarly, an example of regional strategic cooperation can be found in the alliance among the Nordic securities exchanges under the name NOREX, comprising initially the Copenhagen Stock Exchange and Stockholmsbörsen in 1998. Later in 2000, both the Iceland Stock Exchange and Oslo Börs became partners of the NOREX Alliance. The NOREX Alliance envisions implementing a joint cost-efficient marketplace for financial instruments and harmonizing

requirements among the exchanges with respect to trading and membership. To pursue these objectives, the NOREX project follows four strategic principles: cross-membership; a single point of liquidity; a common trading system; and a common regulatory framework. Cross-membership foresees member firms joining all the NOREX exchanges, thereby increasing liquidity and strengthening the Nordic securities market. The single point of liquidity principle requires firms to list their shares on only one NOREX exchange, ensuring that liquidity in the listed firms is concentrated in one market, which contributes to fair price setting. The NOREX partners agreed on a common trading system enabling the exchanges to share technological innovation and establishment costs and to create synergies of costs, which in turn may translate into reduced member fees. In addition, the NOREX exchanges adopted the electronic trading system SAXESS, which was developed by Swedish OM Technology. SAXESS is an order-based system in which orders are automatically matched to a trade when price and volume match. The trading is decentralized, which means that member firms are connected to the system and trade from their home offices irrespective of their geographical location. Concerning the common regulatory framework, it is envisaged not only to harmonize trading rules and membership requirements as well as the training and authorization of brokers in the member countries of the Nordic alliance, but also the listing requirements for companies in order to make it easier for the investor to evaluate the companies on the different NOREX markets.

In derivative markets, Globex Alliance and Eurex have already pooled trading activities in a de facto interconnected single electronic trading platform. Globex Alliance, as a world global electronic trading system, offers remote trading access to its interconnected member exchanges. Under the Globex Alliance, participants in the Chicago Mercantile Exchange (CME), Euronext (formerly ParisBourse), Singapore Exchange Derivatives Trading (SGX), Brazil's Bolsa de Mercadorias & Futuros (BM&F), Spain's MEFF, and the Bourse de Montréal benefit from remote access to all the Alliance markets through a single electronic trading system. The Eurex exchange was jointly launched by the German Deutsche Börse AG and the Swiss Exchange through the merger of the formerly DTB Deutsche Terminbörse und SOFFEX (Swiss Options and Financial Futures Exchange) in 1996. Eurex provides direct electronic access to a wide range of derivative products. In contrast, LIFFE continued running a floor-based market until the late 1990s. However, by the second half of the decade technological advances started dramatically reshaping the derivative market. As customers began to gravitate towards electronic markets at a much lower cost base, LIFFE were no longer able to operate a competitively floor-based market for financial products. In 1998, LIFFE's market share of trading German Government Bond futures and options contracts rapidly fell from 70% to zero, as traders shifted all their orders in the Bund contracts to Eurex, which was able to provide London-based customers with remote access facilities through its screen-based trading platform. As a result, the

rapid emergence of Eurex relative to UK based LIFFE affirms that cost efficiency and the importance of network economics play a dominant role in the efficient microstructure of trading systems. Since the beginning of 2002 LIFFE has joined the Euronext Group and represents the derivative business of Euronext. The combination of Euronext and LIFFE's derivative operations is mainly designed to achieve economies of scale and scope by providing customers, through a single trading platform, access to a deep market with a wide range of complementary products. All of the combined entity's derivatives businesses are to be transacted on the LIFFE CONNECT^{TM} system, LIFFE in-house electronic trading platform developed only recently, offering market participants remote trading access. In this way greater distribution as a result of the access of Euronext's members to LIFFE CONNECT^{TM} is aimed at increasing the quality of the market by improving liquidity and price information.

Different projects and strategies of collaborative arrangements among European stock exchanges were described in this section. Although some of the surveyed deals among stock exchanges have failed or were abandoned, it seems apparent that Europe is increasingly a favourable environment in which stock exchanges pursue cooperative strategies in order to build up networked markets and create additional value in the provision of their trading services. The views expressed in the literature are rather mixed in respect of the advantages and success of network-creating activities in the stock exchange industry. For example, some authors assess sceptically the prospects of a networked stock exchange organization in Europe (Licht 1998, Steil 1996). Their hypothesis centres chiefly on the argument that a strategy of enhancing competition is more likely to foster stock market integration than the networking model. Others, such as Cybo-Ottone, Di Noia, and Murgia (2000), and Di Noia (2001), emphasize the positive effects of competition and integration among stock exchanges in Europe through network effects and implicit mergers. Addressing these controversial statements in this research field, the following section analyses empirically the implications of network externalities for liquidity, trading costs, and growth in securities markets in Europe.

3 Recent literature on network externalities and stock exchanges

The concept of network externalities is developed in the New Theory of Industrial Organization and represents an important field in economics, as it applies to a variety of industries, such as telecommunications, airlines, railroads etc. Shy (2001) presents an array of topics in network economics focusing on strategic interactions that network activity creates between firms and its impact on consumers' choices of products and services.[4]

A network externality can be defined as a production or consumption positive size externality. Formally, networks consist of links that connect nodes. In a typical network, the addition of a new consumer (or network node) increases the willingness to pay for network services among all participants. This effect is called network effects or network externalities. Several authors apply the concept of networks to financial intermediation and securities markets. Regarding a financial exchange network, Domowitz (1995) and Domowitz and Steil (1999) state that an exchange or a trading system is analogous to a communication network, as the benefit to one trader transacting in a given trading system increases when another trader chooses to transact there as well. Following Economides and White (1993), a central financial exchange is a one-way network.

Economides (1996) points out that there are two ways in which financial exchange networks exhibit network externalities. First, the act of matching buys and sells for goods or assets generates a composite good, namely the exchange transaction. It is important that a critical mass of counteroffers is available. In financial terms, minimal liquidity is required for the transaction to occur. Second, network effects may also stem from different vertically related services necessary for a financial transaction, ie the matching services of brokers. However, the first type of externality seems to be more pronounced in financial markets.

Positive size externality is an essential property of financial market networks in the sense that the expected utility for all network participants positively depends on the thickness of the exchange market. Economides and Siow (1988) show that liquidity considerations limit the number of markets in a competitive 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) argued 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

[4] An interactive bibliography on the network-externalities literature and related issues applied to finance can be found online at http://www.stern.nyu.edu/networks/biblio.html.

Economides, this opens up the possibility that some market structures (such as monopolies), which can co-ordinate expectations, might achieve larger networks and higher welfare than would perfect competition. Network providers have market power through the setting of standards for the network. Stock exchanges usually set rules and regulations for their trading systems. This, according to Economides, impedes technological innovation. He argues that equilibrium price information from a financial exchange network is another externality, in addition to market liquidity. A concern here stems from the 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. It is also seen 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 the quality of the market price worse. A solution suggested by Economides is to price market equilibrium information appropriately. This question relates to legislation and interim rules and regulations as well as the microstructure of trading systems of stock exchanges and specifically those of alliances.

Liquidity plays a pivotal role in financial exchange markets where order-flow attracts order-flow. According to research of Economides (1993) and Economides and Siow (1988), the spatial consolidation of markets tends to increase liquidity. Subsequent proposals by Economides and Schwartz (1995a) suggest time the consolidation of markets in the form of an electronic call market integrated in the continuous trading environment in order to create liquidity. The authors advocate the introduction of electronic calls and discuss, from the perspectives of investors, listed companies, exchanges, brokers, and regulators, the advantages of this innovation in respect to enhancing liquidity, order handling, information revelation, market transparency, market anonymity, and avoidance of free-riding. Similarly, Economides (1995) argues that call markets provide coordination of many transactions in the time dimension, and thus increase liquidity and reduce transaction costs for public participants. In sum, call markets bear higher liquidity because they take advantage of network externalities.

From a similar perspective concerning the design of electronic markets, Gode and Sunder (2000) claim that technological constraints create a conflict between achieving simultaneously a continuous market mechanism with a geographically dispersed trader population on the one hand and ensuring equal market access on the other. To provide equal access more easily, the authors argue in favour of electronic global exchanges that should ideally be call markets with more frequent calls, such that they are close to continuous markets.

Given the importance of liquidity for traders and their risk aversion, traders have an incentive to delay the placement of an order in a call market, thereby benefiting from the closeness of the time of the order to participate in the call

market and benefiting from the committed level of liquidity at this point in time. When traders wait until the last moment, there is significant uncertainty in the number of traders participating at the call. Economides and Heisler (1994) discuss how to increase liquidity at the call. They envision a proprietary electronic call market with a time-dependent commission schedule offering discounts in trading costs to traders who commit to early participation in the market.

In general, it is believed that market participants seek immediate execution of their transactions. Economides and Schwartz (1995b) investigated the demand for immediacy of order execution in a questionnaire sent to major equity traders. The principal finding is that the majority of traders would opt for a delay in trade if this decreased execution costs. Alternative electronic trading systems are generally seen as attractive alternatives in respect to reduced market impact, lower spreads, better liquidity, and anonymity.

Complementarity, compatibility, and standards are other important characteristics that are inherent in many networks (Farrell and Saloner 1986, Katz and Shapiro 1985, 1986). On the technical side of network industries, compatibility is an essential element in the market structure for network goods. Regarding the choice of a technical standard, Economides and Flyer (1998) analyse the tradeoffs that firms are facing in competitive markets where network externalities are present. In their model, they contrast the conflicting benefits arising from adhering to a leading compatibility standard versus the advantages of adopting unique standards associated with less intra-platform competition, but also with less added value by a large network. As a result, the authors state that market equilibria often show extreme asymmetries in firms' profits and output, while using the same production technologies. The authors relate this finding to the fact that often only one or very few firms dominate network industries. For example, the success of Eurex relative to the UK-based London International Financial Futures Exchange (LIFFE) may be partly explained by differences in the technical compatibility standards of these exchanges.

In a game-theoretic framework, Di Noia (2001) addresses the possible effects of cross-network externalities on competition and consolidation in the European stock exchange industry. It is demonstrated that competition may lead to inefficient equilibria, while implicit mergers among exchanges together with remote access may have a Pareto optimal outcome and may result in higher profitability for exchanges and consumers. The model suggests that implicit mergers and remote access can be helpful for specializing in listing or trading services. The recent success of automated trading systems supports this finding, as they achieve unilaterally compatibility by trading stocks listed on other exchanges, given their strong cost advantage.

Analysing market implications of alliances among stock exchanges, Shy and Tarkka (2001) establish that alliances are very likely to improve total welfare as well as to increase profits for stock exchanges, depending most importantly on the

exchanges' ability to reduce the costs of foreign share purchases. In turn, brokers or investors were not seen to benefit from the creation of exchange alliances, irrespective of improved social welfare. As a result, the authors anticipate the possibility of the amalgamation of brokerage and stock exchange functions in the near future.

Cybo-Ottone, Di Noia, and Murgia (2000) analyse selected types of deals among stock exchanges over time according to legal structure, technical integration, status, location, and area. However, they do not study empirically network and cross-network effects among stock exchanges.

Madhavan (2000) and Sirri (2000) explore how technological progress and the process of regulatory arbitrage shape modern equity markets and enable new venues for trade. As a result of these factors, market fragmentation associated with diminished liquidity and higher intra-day volatility seems to pose a major challenge for central regulators and policy makers as they in turn aim to promote competition and encourage innovation. Likewise, alternative trading venues also alter the competitive norms of brokers traditionally being exchanges' customers.

Strong network externalities force exchange markets to create formal or informal linkages. The exact design of such inter-connections is less important. They are likely to occur in the form of implicit and explicit acquisitions and mergers, strategic alliances, simply pooling order-flows, or even information sharing agreements as discussed in Domowitz and Steil (1999). Financial exchanges that are less active in forming alliances or linkages are likely to lose competitive ground vis-à-vis their counterparts engaging in network strategies.

The existing literature on networks that relates to stock exchanges or to financial intermediaries is theoretical or descriptive in nature. We are not aware of any empirical literature particularly dealing with network economics among the exchanges. A number of articles – as mentioned earlier – focused on the impact of cross-listing across exchanges and evaluated its impact on stock prices[5] Additionally, Cybo-Ottone, Di Noia and Murgia (2000) outlined the merger of exchanges during the 1990s; however, they did not investigate any likely association between networks or implicit mergers with different elements of exchange-specific firm performance, volatility, and efficiency. Thus, there is an obvious need for empirical research in this area. This study attempts to fill this gap.

[5] See Blass and Yafeh (2001), Chaplinsky and Ramchand (2000), Foerster and Karolyi (1993), Karolyi (1998), and Pagano, Röell and Zechner (2002).

4 Data and methodology

Our empirical approach in this paper is to trace the potential relationship between network variable(s) and several measures of exchange performance and efficiency. These performance and efficiency measures include market capitalisation, the growth of market capitalisation, turnover velocity, the transaction costs of trading and the operating costs of the respective exchanges. The estimations control for other pertinent variables that are likely to affect stock exchange performance and efficiency, such as the local economic environment, the relative importance of the private sector, accounting or disclosure standards, market monopoly by the largest firms, the costs of trading, market competition and size.

The data used in this study come from a variety of sources, including annual reports of stock exchanges, various issues of the International Federation of Stock Exchanges (FIBV), IMF International Financial Statistics (IFS), Elkins/McSherry, and information from exchange Internet sites. Most of the data were collected from annual balance sheets, income statement reports, and the Internet pages of all major operating stock and derivative exchanges covering a 5-year time period (Annual Reports 1996–2000). In some cases, additional information was obtained from the exchanges through correspondence. Also various issues of the MSCI Handbook served as an important source of information on exchange-specific characteristics, such as the concentration of market share of the top three companies in each market (a proxy for market monopoly by largest firms) as well as the number of additional exchanges in the country (market competition) where the sample exchange is located.

Although reporting schemes and the information content of the financial accounts vary across time and exchange, a consistent data set has been constructed including all necessary information on 24 individual exchanges' key balance sheet and income statement items, of which 120 observations over the period 1996–2000 finally entered into the estimations. All national currencies are converted into USD and are inflation-adjusted using data from IFS. All variables other than qualitative proxies are expressed in natural logarithms.[6,7] The accounting or disclosure standard is constructed by using the CIFAR index to measure the quality of accounting disclosure, a method used previously by researchers. The CIFAR index used in the existing literature represents the average number of 90 specific items disclosed in the annual reports of at least three companies per country, including items from the company's income

[6] In constructing the growth variable, we have also used 1995 data.

[7] See Schmiedel (2001) for more details on the European sample exchanges.

statement, balance sheet, statement of cashflows and notes to the financial statements. The maximum score a country can obtain is 90.[8]

In order to examine network effects among stock exchanges, a data set has been compiled including all major inter-market connections along different types of exchange markets in the European Union. Since networks among exchanges is more frequent and plays an important role in European markets, we focus in this study on EU linkages. Accordingly, the network linkages in our data set include two or more entities where at least one entity is a European exchange. Figure 1 portrays all strategic cooperation, network experiences, and announcements among European stock and derivative exchanges by the year 2002. Building on this diagram, we traced back the development of each network to its year of implementation and establishment. The experience of European exchanges from the mid-1990s to 2002 shows that network strategies are only quite recent phenomena. The total number of such linkages considerably increased after 1997/98.

A classification of network linkages has been made according to different market categories in order to control for compatibility among different types of networks. This is in particular important since stock exchanges are engaged in multiple transaction and trading services in various stock and derivative markets. As already mentioned in Cybo-Ottone, Di Noia, and Murgia (2000), the classification of networks is not a straightforward exercise, given only limited access to information and details in respect of announcements, implementation status and network members. Against this background, the underlying categorisation in this paper may, however, slightly differ from schemes employed in related studies or official views stated by the exchanges themselves.

Different NETWORK variables were constructed in order to examine network externalities in financial exchange markets. The first variable included in this study controls whether an exchange generally pursues any kind of network strategy. If an exchange is engaged in networks and maintains/offers network access the variable ACCESS takes a value of one, otherwise zero. Secondly and more specifically, the total number of different types of networks, NDN, captures the fact that exchanges build-up various connections with varying network partners. Therefore, the variable NDN proxies the overall network activity of such exchanges that have successfully established different and not necessarily fully compatible network connections with other participating exchanges. Based on the theoretical considerations proposed in Section Two, however, the value of a network increases exponentially with each new participant that enters the network. Accordingly, the third variable, NNM, accounts for all members that are connected via each market's network.

[8] LaPorta et al (1997, 1998) have used this source to identify the accounting standard.

Furthermore, a key factor for analysing these networks is to distinguish them along different types of securities segments. In respect to the total number of stock exchanges linked through networks, these market interconnections were classified along three criteria: blue chip equity markets, derivative markets, and new markets for innovative and mostly high-tech oriented companies. Equity markets account for inter-linkages and cooperation among exchanges that were established primarily for trading in all major blue chips. Derivative markets capture networked trading platforms for options and financial futures, while new growth and tech-oriented markets comprise interconnections of markets with newly listed high-growth and innovative-oriented firms. Figure 1 plots all major established network connections of European exchanges by 2002 classified according to the criteria discussed above.

Transaction costs data for each European exchange market come from Elkins/McSherry (E/M) Universe. This is a rolling four quarter compilation of data comprising current and historical information on 700 global managers and 800 global brokers, containing average commissions, fees, market impact and stock price information from 208 exchanges in 42 countries. Although an assessment of the quality of trading is beyond the scope of this trade execution data, it, however, enables a comparison of commissions, fees, and market impact to a universe of costs in different countries.

The E/M system calculates the cost of trade execution on the basis of the volume weighted average price and the spreads of the stocks.[9] The E/M data contains all time of each trade including the high, low, open and close, volume traded, volume weighted average price and average spread. The market impact, being considered as a major cost component of the transaction cost, is calculated by E/M as the difference between the trade execution price and the average price (high, low, open, and close) for every stock in 42 countries daily. Commissions, fees and market impact costs are compared to the average institutional costs in each country and then broken down by portfolio manager, account, client and broker. Finally, the summary costs for each institution enter into the E/M Universe of average costs. The total trading cost is measured in basis points representing the average sum of commission, fees and market impact based on trade data on all global trades executed by large institutional investors in a given market.

Following the FIBV statistics, turnover velocity controls for the quality of each particular market. The velocity of an exchange is computed as the annualised ratio of the monthly average turnover of domestic shares to their month-end market capitalisation. Finally, macroeconomic information such as GDP per capita, and concentration of private sectors is taken from the IFS data bank.

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[9] Consult http://www.elkins-mcsherry.com/edata.html for an example of volume weighted average price and spread calculations.

As mentioned earlier, the estimation model in this paper investigates the potential relationship between the NETWORK variable(s) and exchange PERFORMANCE and EFFICIENCY measures as portrayed by equations 4.1 and 4.2. As evident, we employ a series of ordinary least squared regressions to capture these potential relations. First, we investigate the relationship with a number of simple single variable regressions (4.1), later followed by multivariate estimations (4.2) incorporating other control variables that are pertinent to the exchange performance measures. Market capitalisation (MKTCAP), the growth of market capitalisation (GMKTCAP), turnover velocity (TURNOVER), the transaction costs of trading (TCOSTR), and operating costs (OPCOST) are used as proxies for the dependent variables.

$$\text{PERFORMANCE}_{it}\ (\text{EFFICIENCY}_{it}) = \alpha_0 + \text{NETWORK}_{it} + \varepsilon_{it} \tag{4.1}$$

$$\text{PERFORMANCE}_{it}\ (\text{EFFICIENCY}_{it}) = \alpha_0 + \text{NETWORK}_{it} + \\ + \sum \text{CONTROL VARIABLES}_{it} + \varepsilon_{it} \tag{4.2}$$

The NETWORK variable is represented by alternative variables. The first three estimates are based on the variables that trace (1) ACCESS; (2) NDN; (3) and (3) NNM respectively. The next three regressions follow the definition of NETWORK portrayed in (3), ie, NNM, except in each case, it considers the total number of other exchanges linked with an individual exchange via an (4) Equity or Blue Chip Network (ENNM); or (5) Tech. or Growth Network (TNNM); or (6) Derivative Network links (DNNM). Although our interest is primarily focused on the first four estimates, it is however interesting and informative, when detailed information is available, to investigate the relative importance of specific types of network or impact in connecting with other exchanges.

Control variables considered are: GDP per capita in the country where the exchange is located (local economic environment); total Private Sector Accumulation to GDP ratio (relative importance of private sector); Disclosure Index (accounting or disclosure standards in CIFAR); Concentration of Ownership by the top three firms in the Exchange, (extent of influence of larger firms in the exchange); Transaction Cost (cost of trading); Number of Exchanges within the Domestic Borders (competition in the exchange business); and Market Capitalisation (market size). These control variables are selectively added to each regression, given what is considered as exchange performance (dependent

variable) in a particular estimation, and are consistent with the relevant literature.[10]

5 Empirical evidence

Table 1 provides the names and a number of key statistics for each of the sample exchanges. These statistics include average market capitalization, turnover velocity, transaction cost of trading and the extent of their involvement in exchange networks during the sample years. It reveals that the exchanges are of different sizes of market capitalisation. An interesting observation in this respect is that the turnover, transaction costs, and network involvement are not necessarily always proportional to size. Many smaller exchanges report higher turnover, lower transaction costs, and higher involvement in network cooperation.

Table 2A follows with mean, standard deviation and the range of key variables of the overall sample. The Riga exchange of Latvia has the smallest market with a market capitalization of USD 289 million, while the London stock exchange represents the largest market of USD 2,474,579 million in a given sample year respectively. On average the markets are growing at a rate of almost 29% with a varied range of turnover velocity. The transaction costs range from as low as 23.80 (Paris exchange) to as high as 161.01 (Czech Republic) in a given sample year. The maximum number of network links available to exchanges in Europe is four and the total number of stock exchanges linked through networks as high as 19 exchanges. These sample exchanges are from countries with a wide range of GDP per capita, private sector involvements and accounting standards. A more detailed analysis of the network variable(s) and some of their components is shown in Table 2B. It reports the extent of network links by different types of networks, ie Derivative Network. The correlation coefficient of all key variables used in this paper is shown in Table 3. In summary, the relationships between these variables are consistent with expected magnitudes and significance.

[10] GDP Per Capita and Private Sector Accumulation to GDP ratio are taken from International Financial Statistics and are adjusted for inflation and converted into US dollars. Concentration of Ownership, and Number of Exchanges are taken from the MSCI Handbook; Disclosure Index has been taken from La Porta et al (1997) and cross-checked with the CIFAR Index; Transaction Cost, which is used as a dependent variable in some estimates and as an independent variable in others, is from Elkins-McSherry. As mentioned in the text, the Network variable is constructed by tracing the developments of stock exchanges over the sample period from different public information sources and on some occasions by writing to the exchanges directly. Additionally, the dependent variables, Market Capitalisation, Growth of Market Capitalisation, and Turnover Velocity are taken from the FIBV and the Operating Cost (OPCOST) comes from the annual reports of respective exchanges during the sample period.

However high correlation coefficients between NETWORK variables (ACCESS, NDN, NNP, and NNM) suggest that any estimate that incorporates all of the above Network variables in the same regression would suffer from severe multicollinearity problems.

These initial sets of single equation estimates are reported in Tables 4A to Table 4E. In each table, we provide results of the possible impact of all alternative NETWORK variables (or components of it) on one of the exchange PERFORMANCE measures. To illustrate, Table 4A reports the potential relationship between the logarithm of market capitalisation with five different independent variables in five separate estimates. The evidence portrayed here reveals overwhelmingly a positive and significant association between NETWORK variable(s) and market capitalisation. Interestingly, we observe that in each of the reported regressions, the model statistics, ie adjusted R-squared and F-Statistics, are quite high and significant. For example, the first regression of Table 4A shows that over 35% of the market capitalisation variability of the sample is captured by a simple bivariate independent variable.

In Table 4B market growth is considered as the dependent variable, calculated by taking the annual growth of market capitalisation of the respective exchanges.[11] The evidence shows a strong association between NETWORK variable(s) and market growth. Next, we turn to inquire about a possible association of NETWORK variables with TURNOVER in the market. The turnover velocity reflects the efficiency of the exchange. These results are reported in Table 4C. Although model statistics reported here are relatively weak, the coefficients of the NETWORK variable are significantly and positively associated with the dependent variables, in this case with TURNOVER.

We then focus our attention on the possible relationship between the NETWORK variable and the TCOSTR (transaction cost of trade) in respective markets. Exchanges with higher network linkages are expected to be associated with lower trading costs. Evidence in Table 4D reports high model statistics, and importantly for our purposes, all NETWORK variables are found to be negatively and significantly associated with TCOSTR. Next we replace cost of trade as a dependent variable with the operational cost of an exchange to market capitalisation ratio (OPCOST), described in Table 4E. The estimates here are designed to see whether the NETWORK variable(s) have any relationship with the usual operational costs – costs reflected in the financial statements – of an exchange. One may expect that the newly developed network links may increase the operational costs in running day-to-day exchange businesses. On the contrary, it can be also argued that such a link would lower the marginal cost as well as the total cost of exchange operations due to the economies of scale and scope in

[11] We include 1995 market capitalisation data for the sample exchanges in order to calculate the growth variable.

attracting new listings or volumes. Our evidence reports a negative and significant relationship primarily on the first three estimates. The model statistics of these regressions were relatively low.

We follow-up estimations in Table 4A–E with another set of estimations as portrayed in Table 5A–C with the exception that we proceed with reporting only the first four estimates (rather than the seven represented in 4s) ie, representing a relatively broader proxy for NETWORK variables. In these regressions, we also control for additional variables that may be pertinent in explaining all the dependent variables used in our regressions. These variables were selected based on similar use of these variables in the literature in different research contexts. Most of the independent variables used in Table 5A–C are quite similar across regressions, except for an additional size variable (market capitalisation) used in the two cost regressions, 5B and 5C. Once again, these independent variables were controlling for the macroeconomic environment, incorporating: GDP per capita; the relative importance of the private sector in the economy, considering the total private sector accumulation to GDP ratio; accounting or disclosure standards of the economy where an exchange is located; relative concentration of the top three firms in the exchange; the cost of trading (as relevant for specific dependent variables); and the number of exchanges within the domestic borders, a proxy for market competition. In summary, even after adding all other independent variables in our estimations, we find our key focus variables represented by NETWORK (ACCESS, NDN, and NNM) are still significantly associated with dependent variables in most estimations. Indeed, their relative significance – or t-statistics – were not as strong as the ones reported in Table 4A–4E, where no control variables were added to the NETWORK variables. Nonetheless, they are relevant and significant in explaining the variability of dependent variables. Moreover, the marginal increase in model statistics due to the addition of several new independent variables reveals that the R-squared represented by NETWORK variable(s) takes the lead in explaining the variability of exchange performance.

Table 1. **Sample European capital markets, 1996–2000**

Name and Country of the Exchange	Market Capitalisation (Thousands of USD)	Turnover-Velocity In the Market	Transaction Cost of Trading	Extent of Network Involvement	Number of Total Stock Exchanges linked through Network
Amsterdam – Netherlands	611,881,123	63.91	32.61	0.80	3.20
Athens – Greece	100,011,452	76.96	77.25	0	0
Brussels – Belgium	191,121,752	23.76	35.12	0.80	3.20
Copenhagen – Denmark	101,466,314	57.28	39.64	0.40	1.20
Frankfurt – Germany	1203,214,712	123.75	32.11	1.40	4.80
Helsinki – Finland	214,126,751	48.81	41.90	0.40	1.60
Dublin – Ireland	64,142,512	54.38	104.51	0	0
Istanbul – Turkey	57,286,049	140.73	60.08	0	0
Lisbon – Portugal	53,276,152	56.03	52.44	0.60	4.80
Ljubljana – Slovenia	2,126,019	34.70	n.a.	0	0
London – UK	1924,869,663	47.56	72.61	1	2
Luxembourg – Luxembourg	40,568,432	2.91	82.82	0	0
Madrid – Spain	375,954,841	155.66	42.73	0.60	4.80
Oslo – Norway	62,907,938	77.51	38.21	0.20	0.80
Paris – France	1140,873,128	60.11	29.04	1.40	8.00
Stockholm – Sweden	334,893,180	70.90	32.52	0.40	1.20
Zurich – Switzerland	715,898,118	78.31	38.33	0.60	2.00
Vienna – Austria	39,866,283	38.20	43.99	0.20	0.40
Warsaw – Poland	17,347,631	61.35	n.a.	0	0
Budapest – Hungary	11,140,044	n.a.	104.65	0	0
Reykjavik – Iceland	2,829,086	n.a.	n.a.	0	0.80
Malta – Malta	1,010,668	n.a.	n.a.	0	0
Prague – Czech Republic	10,829568	n.a.	111.99	0	0
Riga – Latvia	225,421	n.a.	n.a.	0	0

Table 2A. **Descriptive statistics**

Variables / Ratios	Mean	Standard Deviation	Minimum	Maximum
Market Capitalisation (thousands of USD)	366,006,527	588,957,820	289,125	2474,579,290
Market Capitalisation Growth	48.681	130.016	32.047	238.435
Turnover – Velocity	62.84	45.81	5	196
Transaction Cost of Trading (average fee)	54.55	28.98	23.803	161.005
Operation Cost of the Stock Exchange (thousands of USD)	80,421	136,147	706	721,074
Access to Network (Yes/No)	0.458	0.500	0	1
Extent of Network Involvement	0.591	0.770	0	4
Total Number of Stock Exchanges Linked through Network	2.285	3.636	0	19
GDP Per Capita (000)	21.337	11.151	3.056	39.071
Concentration of Private Sector to GDP	0.363	0.454	0.052	0.736
Accounting Standard	63.66	11.696	36	83
3-Firm Concentration on the Exchange	32.681	22.001	3	78
Number of Exchanges In the Country	2.166	2.145	1	9

Table 2B. **Descriptive statistics**

Variables / Ratios	Mean	Standard Deviation	Minimum	Maximum
Access to Network (Yes/No)	0.458	0.500	0	1
Extent of Network Involvement	0.591	0.770	0	4
Total Number of Stock Exchanges Linked through Network	2.285	3.636	0	19
Total Number of Stock Exchanges Linked through a Blue-Chip Equity or Equity Network	0.343	1.006	0	4
Total Number of Stock Exchanges Linked through a networked market for Growth or Tech-oriented Companies	0.416	1.389	0	5
Number of Total Stock Exchanges Linked through a Derivative Network	1.24	2.57	0	11

Table 3. **Correlation coefficient matrix**

Variables / Ratios	1	2	3	4	5	6	7	8	9	10	11	12	13
1. Market Capitalisation	1	0.40***	0.24**	–0.25*	0.75***	0.47***	0.63***	0.53***	0.30**	0.84***	0.40***	–0.36***	0.59***
2. Market Capitalisation Growth		1	0.61***	–0.43***	0.37***	0.46***	0.37**	0.30**	0.04	0.34**	–0.02	–0.21	0.33**
3. Turnover – Velocity			1	–0.38***	0.39***	0.30**	0.26**	0.32**	–0.27*	0.17	–0.14	–0.31**	0.55***
4. Transaction Cost of Trading				1	–0.37**	–0.57***	–0.40***	–0.43***	–0.31*	–0.05	–0.21	0.15	–0.25**
5. Operation Cost of the Stock Exchange					1	0.43***	0.60***	0.52***	0.24	0.51***	0.12	–0.34***	0.66
6. Access to Network (Yes=1No=0)						1	0.71***	0.63***	0.50***	0.38***	0.13	–0.11	0.41***
7. Extent of Network Involvement							1	0.92***	0.45***	0.51***	0.09	–0.18	0.44***
8. Total Number of Stock Exchanges Linked through Network								1	0.38***	0.24*	–0.05	–0.09	0.42***
9. GDP Per Capita (000)									1	0.21	0.50***	0.12	0.09
10. Concentration of Private Sector to GDP										1	0.23	–0.37**	0.51***
11. Accounting Standard											1	0.09	0.05
12. 3-Firm Concentration on the Exchange												1	–0.30**
13. Number of Exchanges In the Country													1

Note: ***, **, * portray significance at the 1, 5 10 percent levels respectively.

Table 4A. **Orninary least square estimates – Network on market performance**

Independent Variable/Ratios Model	Dependent Variable Market Capitalistaion 1 Parameter (t-statistics)	2 Parameter (t-statistics)	3 Parameter (t-statistics)	4 Parameter (t-statistics)	5 Parameter (t-statistics)	6 Parameter (t-statistics)
Intercept	6.784 (30.16)***	7.314 (44.03)***	11.43 (65.01)***	17.965 (70.52)***	17.819 (78.53)***	17.550 (76.93)***
Access to Network (Yes=1 – No=0)	2.772 (7.89)***	–	–	–	–	–
Extent of Network Involvement	–	1.618 (6.84)***	–	–	–	–
Total Number of Exchanges Linked through Network	–	–	0.304 (5.98)***	–	–	–
Total Number of Stock Exchanges Linked through the Equity Network	–	–	–	0.413 (2.62)***	–	–
Total Number of Stock Exchanges Linked through a networked market for Growth or Tech-oriented Companies	–	–	–	–	0.566 (3.49)***	–
Total Number of Stock Exchanges Linked through Derivative Network	–	–	–	–	–	0.401 (4.81)***
Adjusted R-Squared	0.352	0.302	0.239	0.105	0.118	0.144
F-Statistics	52.60***	39.03***	28.68***	9.80***	12.19***	23.17***
Number of Obs.	120	120	120	120	120	120

Note: ***, **, * portray significance at the 1, 5, 10 percent levels respectively.

Table 4B. **Orninary least square estimates – Network on market growth**

Independent Variable/Ratios Model	Dependent Variable Market Capitalisation Growth					
	1	**2**	**3**	**4**	**5**	**6**
	Parameter (t-statistics)	**Parameter (t-statistics)**	**Parameter (t-statistics)**	**Parameter (t-statistics)**	**Parameter (t-statistics)**	**Parameter (t-statistics)**
Intercept	13.600 (5.65)***	16.480 (4.98)***	9.892 (4.59)***	11.450 (3.91)***	8.265 (3.53)***	9.704 (4.46)***
Access to Network (Yes=1 – No=0)	1.650 (3.59)***	–	–	–	–	–
Extent of Network Involvement	–	3.582 (2.83)**	–	–	–	–
Total Number of Exchanges Linked through Network	–	–	1.364 (2.17)**	–	–	–
Total Number of Stock Exchanges Linked through the Equity Network	–	–	–	0.127 (1.68)*	–	–
Total Number of Stock Exchanges Linked through a networked market for Growth or Tech-oriented Companies	–	–	–	–	0.309 (1.75)*	–
Total Number of Stock Exchanges Linked through Derivative Network	–	–	–	–	–	1.082 (2.19)**
Adjusted R-Squared	0.202	0.122	0.072	0.054	0.048	0.031
F-Statistics	12.92***	7.54***	4.70**	3.65*	3.83*	3.79*
Number of Obs.	120	120	120	120	120	120

Note: ***, **, * portray significance at the 1, 5, 10 percent levels respectively.

Table 4C. **Orninary least square estimates – Network on market efficiency**

Independent Variable/Ratios Model	**Dependent Variable Turnover Velocity**					
	1	**2**	**3**	**4**	**5**	**6**
	Parameter (t-statistics)	**Parameter (t-statistics)**	**Parameter (t-statistics)**	**Parameter (t-statistics)**	**Parameter (t-statistics)**	**Parameter (t-statistics)**
Intercept	6.784 (30.16)***	7.314 (44.03)***	11.430 (65.01)***	17.965 (70.52)***	17.819 (78.53)***	17.550 (76.93)***
Access to Network (Yes=1 – No=0)	2.772 (7.89)***	–	–	–	–	–
Extent of Network Involvement	–	1.618 (6.84)***	–	–	–	–
Total Number of Exchanges Linked through Network	–	–	0.304 (5.98)***	–	–	–
Total Number of Stock Exchanges Linked through the Equity Network	–	–	–	0.413 (2.62)**	–	–
Total Number of Stock Exchanges Linked through a networked market for Growth or Tech-oriented Companies	–	–	–	–	0.566 (3.49)***	–
Total Number of Stock Exchanges Linked through Derivative Network	–	–	–	–	–	0.401 (4.81)***
Adjusted R-Squared	0.094	0.056	0.090	0.045	0.042	.104
F-Statistics	8.50***	6.28***	9.71***	5.06**	4.77**	11.30***
Number of Obs.	114	114	114	114	114	114

Note: ***, **, * portray significance at the 1, 5, 10 percent levels respectively.

Table 4D. **Orninary least square estimates – Network on transaction cost of trading**

	Total Transaction of Trading					
Independent Variable/Ratios	**Parameter (t-statistics)**	**Parameter (t-statistics)**	**Parameter (t-statistics)**	**Parameter (t-statistics)**	**Parameter (t-statistics)**	**Parameter (t-statistics)**
Model	**1**	**2**	**3**	**4**	**5**	**6**
Intercept	4.628 (9.04)***	3.463 (10.18)***	4.514 (11.31)***	6.245 (8.16)***	5.104 (5.65)***	3.102 (4.43)***
Access to Network (Yes=1 – No=0)	–0.063 (1.98)**	–	–	–	–	–
Extent of Network Involvement	–	–0.026 (1.95)*	–	–	–	–
Total Number of Exchanges Linked through Network	–	–	–0.038 (1.93)*	–	–	–
Total Number of Stock Exchanges Linked through the Equity Network	–	–	–	–0.091 (2.00)**	–	–
Total Number of Stock Exchanges Linked through a networked market for Growth or Tech-oriented Companies	–	–	–	–	–0.164 (1.80)*	–
Total Number of Stock Exchanges Linked through Derivative Network	–	–	–	–	–	–0.346 (2.02)**
Adjusted R-Squared	0.2643	0.2518	0.2561	0.1813	0.1455	0.1539
F-Statistics	4.08***	3.93***	4.11***	3.85***	4.16***	4.29***
Number of Obs.	109	109	109	109	109	109

Note: ***, **, * portray significance at the 1, 5, 10 percent levels respectively.

Table 4E. **Orninary least square estimates – Network on operating cost of stock exchange**

Dependent Variable	**Exchange Operation Cost to Market Capitalisation**					
Independent Variable/Ratios	**Parameter (t-statistics)**	**Parameter (t-statistics)**	**Parameter (t-statistics)**	**Parameter (t-statistics)**	**Parameter (t-statistics)**	**Parameter (t-statistics)**
Model	**1**	**2**	**3**	**4**	**5**	**6**
Intercept	0.013 (4.71)***	0.004 (4.09)***	0.003 (4.00)***	0.002 (3.68)***	0.003 (3.72)***	0.003 (3.86)***
Access to Network (Yes=1 – No=0)	–0.005 (2.98)***	–	–	–	–	–
Extent of Network Involvement	–	–0.003 (2.01)**	–	–	–	–
Total Number of Exchanges Linked through Network	–	–	–0.001 (1.86)*	–	–	–
Total Number of Stock Exchanges Linked through the Equity Network	–	–	–	–0.001 (1.41)	–	–
Total Number of Stock Exchanges Linked through a networked market for Growth or Tech-oriented Companies	–	–	–	–	–0.001 (1.44)	–
Total Number of Stock Exchanges Linked through Derivative Network	–	–	–	–	–	–0.001 (1.75)*
Adjusted R-Squared	0.078	0.029	0.023	0.013	0.016	0.023
F-Statistics	8.53***	3.64**	3.12*	2.03	2.08	3.12*
Number of Obs.	92	92	92	92	92	92

Note: ***, **, * portray significance at the 1, 5, 10 percent levels respectively.

Table 5A. **Impact of network access on market capitalisation and market growth**

Dependent Variables	**Market Capitalisation**			**Market Capitalisation Growth**		
Independent Variables / Ratios	**Parameters (t-statistics)**	**Parameters (t-statistics)**	**Parameters (t-statistics)**	**Parameters (t-statistics)**	**Parameters (t-statistics)**	**Parameters (t-statistics)**
Model	**1**	**2**	**3**	**1**	**2**	**3**
Intercepts	14.637 (7.08)***	15.500 (8.15)***	14.810 (7.76)***	14.637 (7.08)***	12.300 (8.55)***	15.930 (2.95)***
Access to Network (Yes=1 - No=0)	0.227 (1.98)**	–	–	0.227 (1.98)**	–	–
Extent of Network Involvement	–	0.631 (2.76)**	–	–	1.450 (1.90)*	–
Total Number of Exchanges Linked through Network	–	–	0.181 (1.96)**	–	–	0.905 (1.77)*
GDP Per Capita (thousands of USD)	0.023 (1.52)	0.033 (1.94)*	0.031 (1.79)*	0.023 (1.52)	0.032 (1.44)	1.905 (1.07)
Concentration of Private Sector to GDP	1.603 (4.87)***	1.508 (4.90)***	1.499 (4.77)***	1.603 (4.87)***	0.832 (1.98)**	1.685 (2.32)**
Accounting Standard	0.065 (5.05)***	0.060 (4.71)***	0.063 (5.00)***	0.065 (5.05)***	1.47 (3.03)***	0.953 (1.76)*
3-Firm Concentration on the Exchange	–0.026 (2.51)**	–0.014 (1.84)**	–0.016 (2.03)**	–0.026 (2.51)**	–0.054 (2.94)***	–0.095 (2.46)**
Transaction Cost of Trading	–0.030 (1.47)	–0.124 (1.30)	–0.002 (0.94)	–0.030 (1.47)	–0.075 (1.33)	–0.745 (1.21)
Number of Exchanges in the Country	–0.700 (1.44)	–0.061 (1.19)	–0.084 (1.49)	–0.700 (1.44)	–0.316 (0.73)	–0.286 (1.31)
Adjusted R-Squared	0.739	0.715	0.723	0.242	0.208	0.217
F-Statistics	14.06***	16.88***	16.33***	5.98**	4.47**	3.86**
Number of Obs.	106	106	106	106	106	106

Note: ***, **, * portray significance at the 1, 5, 10 percent levels respectively.

Table 5B. **Impact of network access on network on market efficiency and transaction costs**

Dependent Variable	**Turnover Velocity**			**Transaction Cost of Trading**		
Independent Variables / Ratios	**Parameters (t-statistics)**	**Parameters (t-statistics)**	**Parameters (t-statistics)**	**Parameters (t-statistics)**	**Parameters (t-statistics)**	**Parameters (t-statistics)**
Model	**1**	**2**	**3**	**1**	**2**	**3**
Intercepts	2.431	2.791	2.648	4.296	4.284	4.232
	(3.01)***	(3.02)***	(2.99)***	(14.54)***	(13.84)***	(14.03)***
Access to Network (Yes=1 – No=0)	0.001	–	–	–0.126	–	–
	(1.89)*			(1.88)*		
Extent of Network Involvement	–	0.001	–	–	–0.032	–
		(1.66)*			(1.80)*	
Total Number of Exchanges Linked through	–	–	–0.001	–	–	–0.042
Network			(1.04)			(1.50)
GDP Per Capita (thousands of USD)	–1.954	–1.596	1.999	–0.012	–0.023	–0.019
	(2.52)**	(2.35)**	(2.60)**	(2.40)**	(3.09)***	(2.82)**
Concentration of Private Sector to GDP	6.017	1.775	1.19	–0.252	–0.236	–0.242
	(1.68)*	(1.71)*	(1.65)	(1.93)*	(1.90)*	(1.90)*
Accounting Standard	–0.111	-0.015	–0.011	0.001	0.001	0.002
	(0.22)	(0.03)	(0.06)	(0.18)	(0.34)	(0.47)
3-Firm Concentration on the Exchange	–0.684	–0.626	–0.619	0.005	0.004	0.006
	(3.15)***	(1.84)*	(1.88)*	(1.54)	(1.46)	(2.05)**
Transaction Cost of Trading	–39.186	–8.720	–5.61	–	–	–
	(1.93)*	(1.92)*	(1.77)*			
Market Capitalisation	–	–	–	–1.065	–1.120	–0.901
				(2.02)**	(2.23)**	(1.96)**
Number of Exchanges in the Country	2.419	2.233	2.684	–0.042	–0.051	–0.035
	(0.96)	(0.88)	(1.06)	(1.80)*	(2.09)**	(1.87)*
Adjusted R-Squared	0.453	0.489	0.525	0.331	0.332	0.321
F-Statistics	9.50***	9.87***	9.38***	3.79***	4.05***	4.24***
Number of Obs.	100	100	100	106	106	106

Note: ***, **, * portray significance at the 1, 5, 10 percent levels respectively.

Table 5C. **Impact of network access on stock exchange operating cost**

Dependent Variable	**Exchange Operation Cost to Market Capitalisation**		
Independent Variables / Ratios	**Parameters (t-statistics)**	**Parameters (t-statistics)**	**Parameters (t-statistics)**
Model	**1**	**2**	**3**
Intercepts	0.005 (6.66)***	0.001 (6.84)***	0.005 (6.63)***
Access to Network (Yes=1 – No=0)	–0.001 (1.73)*	–	–
Extent of Network Involvement	–	–0.001 (1.66)*	–
Total Number of Exchanges Linked through Network	–	–	–0.003 (0.39)
GDP Per Capita (thousands of USD)	–0.001 (4.70)***	–0.001 (5.41)***	–0.001 (5.18)***
Concentration of Private Sector to GDP	0.001 (0.99)	0.001 (0.67)	–0.003 (3.18)***
Accounting Standard	0.0001 (0.43)	0.001 (0.41)	0.001 (0.55)
3-Firm Concentration on the Exchange	–0.001 (5.68)***	–0.001 (3.02)***	–0.004 (3.18)***
Logarithm of Market Capitalisation	–0.001 (1.08)	–0.001 (5.79)***	–0.004 (5.17)***
Number of Exchanges in the Country	–0.0001 (3.60)***	–0.002 (4.03)***	–0.006 (4.31)***
Adjusted R-Squared	0.653	0.659	0.640
F-Statistics	16.89 ***	9.87***	9.33***
Number of Obs.	92	92	92

Note: ***, **, * portray significance at the 1, 5, 10 percent levels respectively.

6 Conclusions

The topic of networks has been very popular in the academic literature; whether they be theoretical or descriptive in nature, no empirical attempt has been made to understand and investigate the actual structure of the network and its impact on market performance. The increasing involvement of stock exchanges in different trading network modules, especially in Europe, warrants further investigation as to whether the adoption of network strategies adds additional value in the provision of trading services. This paper investigates the network externalities among stock exchanges by constructing and quantifying the network strategy and the extent of networks adopted by the European stock exchanges in recent years. This is one of the very first empirical initiatives to explore whether network linkages or common trading platforms among exchanges matter in affecting individual exchange performance. Tracing the experiences of all major European exchanges over the 1996–2000 period, this paper examines the impact of the network effect on market liquidity, growth, turnover velocity, transaction costs of trading and the costs of exchange operations.

All alternative NETWORK variables constructed reveal a strong and significant association with exchange performance. In summary, the empirical evidence clearly reveals that the adoption of a network strategy by stock exchanges is significantly associated with performance measures. As the stock exchanges around the globe are increasingly moving towards a more network-linked market set-up, further empirical attempts are warranted on the impact of network economics on the exchange industry and financial markets.

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