Essays on Stock Exchange Efficiency, Business Models, and Governance

Inaugural-Dissertation
zur Erlangung des Doktorgrades
des Fachbereiches Wirtschaftswissenschaften
der Johann Wolfgang Goethe-Universität
Frankfurt/Main

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2006

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Tag der Promotion:	11.12.2006

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ATS	Alternative Trading System
BOVESPA	Bolsa de Valores de São Paulo
CCP	Central Counterparty
CESR	Committee of European Securities Regulators
CPSS	Committee on Payment and Settlement Systems
CRS	Constant Returns To Scale
CSD	Central Securities Depository
DEA	Data Envelopment Analysis
DMP	Decision Making Power
DMU	Decision Making Unit
DTCC	Depository Trust and Clearing Corporation
EACH	European Association of Central Counterparty Clearing Houses
ECN	Electronic Communication Network
ECOFIN	The Economic and Financial Affairs Council
EOB	Electronic Order Book
ESFRC	European Shadow Financial Regulatory Committee
FESE	Federation of European Stock Exchanges
FIBV	World Federation of Exchanges
IOSCO	International Organization of Securities Commissions
IPO	Initial Public Offering
LSE	London Stock Exchange
MiFID	Markets in Financial Instruments Directive
NYSE	New York Stock Exchange
OECD	Organisation for Economic Co-Operation and Development
OLG	Overlapping Generations
OLS	Ordinary Least Squares
OTC	Over The Counter
PPP	Purchasing Power Parity
R&D	Research and Development
SEAQ-I	Stock Exchange Automated Quotation - International
SFA	Stochastic Frontier Analysis
SGX	Singapore Exchange
Std. Dev.	Standard Deviation
STP	Straight-Through-Processing
SWX	Swiss Exchange
TCS	Trading, Clearing, Settlement
VRS	Variable Returns To Scale
Y-o-Y	Year-on-Year

Chapter 1

Introduction and Summary of Results

Die Börsenindustrie im Wandel

> 'Wir sind eigentlich weder deutsch noch eine Börse. Wir sind ein globales Liquiditätsnetzwerk.' (Werner G. Seifert, 2004).[1]

Die Börsenindustrie hat in den vergangenen zwei Jahrzehnten einen signifikanten Wandel durchlaufen - und das nicht nur in Deutschland. Börsen haben schon längst nicht mehr den Charakter vergangener Tage, in denen ihre Mitglieder auf dem Parkett um Aktienpakete und -kurse von inländischen Unternehmen feilschten und an den genossenschaftlich organisierten Handelsplätzen eher eine vertrauliche Clubatmosphäre herrschte. Eine Vielzahl der Börsen hat den Parketthandel abgeschafft, ist selbst an einer Börse gelistet und orientiert sich primär am Shareholder Value und somit an den Interessen einer internationalen Aktionärsbasis. Mittlerweile existieren Börsenplätze, die mehrere Länder umspannen. Der französisch dominierten Euronext kommt hier eine Vorreiterrolle zu. Aber auch andere Börsen, wie die Deutsche Börse und die Schweizer Börse, haben länderübergreifend ihre Derivatehandelsplattformen vereinigt und mit ihrem Jointventure Eurex die umsatzstärkste Derivatebörse der Welt geschaffen. In jüngster Zeit werden nun auch transatlantische Allianzen zwischen amerikanischen und europäischen Börsen angedacht. Sowohl die Strategie der Nasdaq, die bisher eine Sperrminorität von über 25% an der Londoner Börse hält, als auch die der New York Stock Exchange, die eine Fusion mit der Euronext anstrebt, belegen dies.

Zudem stehen Börsen mittlerweile in direktem Wettbewerb mit ihren Kunden und ehemaligen Eigentümern, den Finanzintermediären wie Banken und Wertpapierhäuser. Sie konkurrieren um Wertpapieraufträge von Investoren, da Banken nicht mehr jede Order automatisch an sie weiterleiten. Stattdessen versuchen manche Finanzintermediäre, die erhaltenen Investorenaufträge im eigenen Haus mit einer entsprechenden reziproken Order zusammenzuführen, um somit die Geld-Brief Spanne des Wertpapiers als Gewinn einzubehalten. Diese *Internalisierung* von Auftragsausführungen ist seit einigen Jahren insbesondere in England und Deutschland eine bedeutende Einkommensquelle für Wertpapierhäuser geworden. Gleichzeitig stoßen Börsen immer stärker in Geschäftsbereiche vor, die bislang die Domäne ihrer Kunden repräsentierten. Hier sei der Handel von bestimmten Kreditderivateprodukten genannt, die bisher außerbörslich zwischen großen Wertpapierhäusern gehandelt wurden. Sowohl die Chicago Mercantile Exchange als auch die Eurex planen den Handel dieser Titel auf ihren eigenen Plattformen. Ein weiteres Beispiel ist die vertikale Integration von Wertpapierabwicklungs- und Wertpapierverwahrungsgeschäften. Große internationale Banken wie BNP Paribas, Citigroup und State Street kämpfen hier gegen Börsen um Marktanteile.

Wie kam es zu dem hier beschriebenen Wandel? Der entscheidende Katalysator ist der gestiegene Wettbewerbsdruck auf traditionelle Börsen, welcher in vielen Fällen zu einer Umstrukturierung ihrer Organisationsform und Eigentümerstruktur führte. Diese neu ausgerichteten Börsen verstanden sich nun als reguläre, gewinnorientierte Firmen, die nicht mehr in erster Linie ihren Kunden, sondern ihren neuen Eigentümern, den Aktionären, verpflichtet waren.

Struktur des ersten Kapitels Im Folgenden werden zunächst die drei wesentlichen Faktoren angesprochen, die den Wettbewerb in der Börsenindustrie erhöhten. Hier wird vor allem Bezug auf die europäischen Märkte genommen, jedoch ist ein Großteil dieser Elemente auch in der Entwicklung in anderen Wirtschaftsräumen vorzufinden. Danach wird die dadurch induzierte Umwandlung der Organisationsform von Börsen und deren Folgen näher beleuchtet. Im Anschluss wird die hierzu bestehende Literatur kurz angesprochen und diejenigen Fragestellungen identifiziert, die bislang nicht ausreichend Beachtung fanden. Schließlich werden vier

[1] Ehemaliger Vorstandsvorsitzende der Deutsche Börse AG

Arbeitspapiere vorgestellt, die sich mit diesen Fragen beschäftigen und den Kern dieser Dissertation darstellen.

Gründe für den gestiegenen Wettbewerbsdruck Zunächst führte die Globalisierung zu einer stärkeren Vernetzung der Finanzmärkte. Investoren fragten vermehrt Wertpapiere ausländischer Unternehmen nach, um etwa eine bessere Diversifizierung ihrer Portefeuilles zu erreichen. Gleichzeitig wählten Kapital suchende Unternehmen nicht mehr ausschließlich eine Heimatbörse für einen Börsengang aus, sondern erwogen Listings auch an ausländischen Börsen. Der geringere *home-bias* dieser beiden Hauptkundengruppen von Börsen und Finanzintermediären führte damit zu einem höheren Wettbewerb um internationale Wertpapierhandelsflüsse und Listings zwischen den Börsen. Als Folge konzentrierte sich der Handel verstärkt auf die Börsen, die die größte Liquidität aufwiesen, weil sich dort auch die niedrigsten Transaktionskosten für Investoren und Emittenten herausbildeten.

Ein weiteres Element, das den gestiegenen Wettbewerb zwischen den Börsen in Europa überhaupt erst ermöglichte, waren nationale und supranationale Deregulierungsmaßnahmen, welche zur Öffnung der Märkte und damit zur Erosion von Markteintrittsbarrieren führten. Die 1986 in Kraft getretenen Big Bang Reformen im englischen Finanzsektor erwiesen sich als Antriebsfeder für weitere, umfassende Deregulierungsmaßnahmen in anderen europäischen Ländern und auf Ebene der EU. Beispielhaft seien die Investment Service Directive (1993) und der Financial Services Action Plan (1999) genannt, die zu einer Deregulierung und Vereinheitlichung der Regulierung auf den europäischen Finanzmärkten führten. Mit der Implementierung des 'Markets in Financial Instruments Directive' (MiFID) wird ab 2007 eine weitere Harmonisierung auf europäischer Ebene angestrebt. Industrieexperten erwarten, dass dies zu einer Zunahme des Wettbewerbsdrucks auf die Börsen führen wird.[2]

Schließlich übten vor allem die Entwicklungen im IT- und Telekommunikationsbereich einen erheblichen Einfluss auf die Wettbewerbssituation im Börsensektor aus. Sie veränderten die Art und Weise des Wertpapierhandels nachhaltig. Der Parketthandel wurde vielfach durch ein elektronisches Orderbuch substituiert. Des Weiteren ist keine physische Präsenz der Handelsteilnehmer an der Börse mehr notwendig. Banken und Wertpapierhäuser aus Paris können beispielsweise mittels Remote Membership am elektronischen Handelssystem der Deutschen Börse teilnehmen und auf weitere Intermediäre zur Orderausführung verzichten. Zudem sind zahlreiche neue, rein elektronische Handelsplattformen entstanden, die Alternative Trading Systems (ATS) oder Electronic Communication Networks (ECN) genannt werden und mit traditionellen Börsen um Wertpapieraufträge konkurrieren. Die zuvor erwähnte Internalisierung von Kundenaufträgen bei Banken wurde ebenfalls erst durch den Einsatz einer entsprechenden Transaktionssoftware möglich.

Demutualization von Börsen Durch die veränderten Rahmenbedingungen gelang es der Londoner Börse, mit der Einführung eines elektronisch gestützten Handelssystems (SEAQ-I) Ende der 80er Jahre, erhebliche Marktanteile zu Lasten der kontinentaleuropäischen Börsen hinzuzugewinnen. Die Stockholmer Börse, die durch die Migration des Handels von schwedischen Titeln nach London unmittelbar betroffen war, entschied sich 1993 als erste, eine weitreichende Restrukturierung ihrer Organisationsform durchzuführen. Die bei Börsen übliche genossenschaftliche Unternehmensverfassung, zu englisch 'mutual', deren wesentliche Merkmale in der Regel die gemeinnützige Orientierung, die Einheit zwischen Eigentum und Mitgliedschaft, sowie die demokratische Kontroll- und Entscheidungsstruktur (one-member, one-vote Prinzip) dar-

[2] Siehe Umfrage von KPMG (2006)

stellen[3], wurde zugunsten einer gewinnorientierten, aktionärsbasierten Corporate Governance aufgegeben. Zahlreiche Börsen folgten diesem Beispiel, das allgemein mit dem Begriff *Demutualization* umschrieben wird.

Eine der aus ökonomischer Sicht wesentlichsten Veränderungen stellte bei der Demutualization die Trennung zwischen Eigentum und Mitgliedschaft an der Börse dar. Während Börsen zuvor in der Regel im Besitz ihrer Mitglieder, d.h. Banken und Wertpapierhäuser, waren, sind es nun überwiegend (Outside) Investoren, die lediglich eine finanzielle, nicht aber eine geschäftliche Beziehung mit der Börse haben. Als Folge sind Börsen nun in erster Linie dem Shareholder Value verpflichtet, wohingegen die ehemaligen Kunden-Eigentümer auch ihre eigenen Geschäftsbeziehungen mit der Börse berücksichtigt wissen wollten. Hieraus leiten sich Implikationen für die Wohlfahrt der Börsen sowie für ihre verschiedenen Kundengruppen wie Banken, Wertpapierhäuser, Investoren und Emittenten ab. Zwei prominente Beispiele seien im Folgenden beschrieben:

Erstens erleichterte die Trennung von Eigentum und Mitgliedschaft die Einführung eines konkurrenzfähigen, elektronischen Handelssystems, da opponierende Mitglieder, die durch den Computerhandel den Wegfall ihrer Intermediärsfunktion fürchteten, eine solche Entscheidung aufgrund der veränderten Eigentümerstrukturen nicht mehr blockieren konnten.[4] Im Ergebnis führte die Demutualization dadurch zu einem Wohlfahrtsgewinn für die Börse und ihre Endkunden (Investoren und Emittenten), da sie nun eine kostengünstigere Dienstleistung anbieten konnte. Gleichzeitig rief sie jedoch Wohlfahrtsverluste bei den opponierenden Mitgliedern hervor, die nun geringere Renten im Wertpapierhandel verdienten.

Als zweites Beispiel sei die vertikale Integration von Börsen in das Wertpapierabwicklungsgeschäft genannt. Wie im zweiten Kapitel im Detail diskutiert wird, werfen einige Marktteilnehmer vertikal integrierten Börsen vor, dass sie damit eine Abschottungsstrategie verfolgen, um den Wettbewerb zu ihren Gunsten zu beeinflussen. Sollte dieser Vorwurf berechtigt sein, würde ein solches Verhalten zu Wohlfahrtsgewinnen bei den Börsen und ihren Aktionären zu Lasten von Intermediären, Investoren und Emittenten führen. Daher ist verständlich, dass die Diskussion über die Vor- und Nachteile von vertikaler Integration in Europa erst entbrannte, als die gewinnorientierte und von (Outside) Investoren dominierte Deutsche Börse beschloss, diesen Geschäftbereich hinzuzukaufen. Wäre die Börse hingegen noch in der Hand ihrer Mitglieder gewesen, hätten diese den Zukauf vermutlich weit weniger kritisch gesehen, da sie über ihre Beteiligung an der Börse sowohl von den Gewinnen dieser Investition profitiert, als auch eine ihren eigenen Geschäftsinteressen widerstrebende Preispolitik nicht zugelassen hätten. Dass diese Vermutung durchaus plausibel ist, unterstützt die empirische Beobachtung, dass zum einen vertikal integrierte Börsen weit verbreitet sind. In 2003 etwa, waren 30 der 50 weltweit wichtigsten Börsen in diesem Geschäftsfeld tätig. Zum anderen sind diese Börsen in mehr als zwei Drittel der Fälle (23 von 30) im Besitz von Intermediären.[5]

Bestehende Literatur und Fragestellungen dieser Dissertation Die bestehende Literatur zu diesem Gebiet konzentriert sich bislang vor allem auf die gesamtwohlfahrtlichen Aspekte im Börsensektor, die die Veränderungen im Wettbewerb und in der Corporate Governance herbeigeführt haben. Hart und Moore (1996), (1998), beschäftigen sich zum Beispiel mit der Frage, unter welchen Bedingungen eine (Outside) investorengeführte Börse eine höhere

[3] Für eine umfassende ökonomische Diskussion von Genossenschaften, siehe Hansmann (1996).

[4] Vergleiche Steil (2002), der sehr anschaulich die Anreizwirkungen der verschiedenen Akteure beschreibt.

[5] Quellen: Handbook of World Stock, Derivatives & Commodity Exchange 2001-2004, Jahresberichte der Börsen. Die Daten wurden für ein noch nicht veröffentlichtes Manuskript erhoben, welches in einem Industriereport mit dem Arbeitstitel 'Governance of Market Infrastructure Institutions' erscheinen wird, der von Dr. Ruben Lee, Oxford Finance Group, herausgegeben wird.

Gesamtwohlfahrt erzielt als eine Genossenschaftsbörse. Sie kommen zu dem Ergebnis, dass eine gewinnorientierte Börse effizienter sein wird, wenn der Wettbewerbsdruck relativ hoch ist und die Mitglieder stark heterogene Interessen besitzen. Krishnamurti, Sequeira und Fangjian (2003) untersuchen empirisch, ob ein Unterschied in der Marktqualität zwischen der genossenschaftlichen Bombay Stock Exchange und der 'demutualized' National Stock Exchange existiert. Ihre Resultate zeigen, dass die Marktqualität an der genossenschaftlich organisierten Börse geringer ausfällt. Ein weiterer Literaturstrang beschäftigt sich mit den Auswirkungen von Demutualization auf die regulatorischen Pflichten von Börsen. Marktteilnehmer äußerten die Befürchtung, dass die Qualität der Selbstregulierung unter der Gewinnmaxime der Börsen leiden könnte. Als Begründung wurde angeführt, dass diese Börsen einen Anreiz haben könnten, bei der schwer verifizierbaren Beaufsichtigung der Märkte Kosten einzusparen, um eine höhere Profitabilität zu erreichen. Autoren wie Pirrong (2000), Karmel (2000) und Elliott (2002) haben sich mit dieser Problematik auseinandergesetzt und vertreten die Meinung, dass zum einem die dadurch drohenden Reputationsverluste gegen ein solches Verhalten sprechen und zum anderen ähnliche Anreizkonflikte auch bereits bei nicht gewinnorientierten Börsen bestanden. Des Weiteren existiert eine Reihe von Beiträgen, die sich mit der Vorteilhaftigkeit von vertikalen und horizontalen Integrationsstrategien von Börsen aus der Perspektive der Gesamtwohlfahrt beschäftigen. Die Papiere von Koeppl und Monnet (2003) sowie Tapking und Yang (2004) stehen dabei einer vertikalen Integration eher kritisch gegenüber.

Die Auswirkungen, die der Wandel in der Branche - insbesondere die Veränderung in der Governance - auf die Börsen selbst hatte, ist bislang in der Literatur weit weniger intensiv diskutiert worden. Autoren wie Schmiedel (2001), (2002) sowie Mendiola und Ohara (2003) streifen die Thematik, jedoch besitzen ihre Papiere einen anderen Fokus. Die hier vorliegende Dissertation beleuchtet daher einige Fragestellungen, die sich durch die veränderten Rahmenbedingungen für die Börsen ergeben:

1. Welche ökonomischen Charakteristika herrschen in dieser Branche vor und welche Industriestruktur erscheint vorteilhaft?

2. Welchen Einfluss hat die Corporate Governance von Börsen auf ihre Wettbewerbsfähigkeit? Arbeiten gewinnorientierte Börsen tatsächlich effizienter als genossenschaftlich organisierte Handelsplattformen?

3. Weshalb entscheiden sich Börsen, ihre Organisationsform zu ändern und wie wird das Investitionsverhalten von Börsen dadurch beeinflusst?

4. Welchen Einfluss haben unterschiedliche Geschäftsmodelle, insbesondere vertikale oder horizontale Integration, auf die operative Effizienz von Börsen?

Inhalt des zweiten Kapitels Frage 1 stellt den Hauptfokus des zweiten Kapitels dar, welches das Arbeitspapier mit dem Titel 'Settling for Efficiency - A Framework for the European Union' zum Inhalt hat und in Zusammenarbeit mit Marco Weiß entstand.[6] Das Papier dient als Einstieg in die Thematik und bietet zunächst eine deskriptive, industrieökonomische Analyse der Funktionen der Börsen- und Wertpapierabwicklungsindustrie. Als Evaluierungshilfe dienen hierbei drei Dimensionen der Effizienz: (1) Die statische Effizienz betrachtet, wie die

[6] Das Papier ist bisher in der Working Paper Reihe Finance und Accounting Nr. 151 der Universität Frankfurt erschienen und wurde auf zwei wissenschaftlichen Konferenzen angenommen und vorgetragen (INFINITI Conference on International Finance, Trinity College, Dublin und 'Clearing and settlement of financial markets: Europe and beyond', Cass Business School, London). Es wird demnächst als Kapitelbeitrag im Buch von Marco Weiß mit dem Titel 'Efficient Organizational Design - Balancing Incentives and Power' im Palgrave Macmillan Verlag erscheinen.

verschiedenen Funktionen möglichst kostengünstig erfüllt werden können. (2) Die dynamische Effizienz zielt vor allem auf die Innovationsfähigkeit von Industriestrukturen ab, d.h. es wird erörtert, ob eine betrachtete Industriestruktur Wettbewerb und damit Innovationen in der Zukunft ermöglicht. (3) Systemische Effizienz ist gegeben, wenn sich die zu analysierende Struktur gegenüber systemischen Schocks als robust erweist.

Die hier betrachteten Wertschöpfungsstufen Handel, Abrechnung und Abwicklung zeigen wegen der erheblichen Skalen-, Verbund- und Netzwerkeffekte Charakteristika eines natürlichen Monopols auf, so dass eine Konsolidierung der Aktivitäten auf wenige Plattformen aus Sicht der statischen Effizienz vorteilhaft wäre. Jedoch ist zu befürchten, dass eine zu starke Konsolidierung der Aktivitäten die dynamische Effizienz der Industrie wegen des Fehlens von Wettbewerb beinträchtigen würde. Bezüglich der systemischen Effizienz sind zwei Szenarien vorstellbar: Einerseits bietet eine Konzentration der Risiken auf wenige Plattformen die Möglichkeit des effizienten, zentralisierten Risikomanagements. Andererseits eröffnet eine stärkere Fragmentierung der Märkte eine höhere Zahl von Ausweichmöglichkeiten für die Marktteilnehmer, falls einer von ihnen ausfallen sollte.

In einem nächsten Schritt werden drei Parameter vorgestellt, die die wesentlichen Komponenten darstellen, um ein konsistent konfiguriertes und effizientes Industriedesign zu entwickeln: (1) Die Grenzen der Unternehmung legen fest, inwieweit ein Plattformanbieter vertikal, d.h. entlang der Funktionen der Wertschöpfungskette, integriert sein soll. (2) Der verwendete Kommunikationsstandard, der für die Informationsübermittlung zwischen den Wertschöpfungsstufen eingesetzt wird, kann entweder einen proprietären oder offenen Quellcode besitzen und determiniert die Innovationsanreize auf der einen sowie den Marktzugang für Wettbewerber auf der anderen Seite. (3) Schließlich wird die Organisationsform und Eigentümerstruktur auf den einzelnen Wertschöpfungsstufen betrachtet, d.h. ob eine staatliche, genossenschaftliche oder gewinnorientierte Unternehmensverfassung vorliegt.

Abschließend werden drei idealisierte, konsistent konfigurierte Industriestrukturen vorgestellt, von denen eine, welche als 'Contestable Monopolies' bezeichnet wird, den Ansprüchen nach statischer, dynamischer und systemischer Effizienz am besten genügt: Sie ist gekennzeichnet durch konsolidierte Plattformen sowie offene Kommunikationsstandards. Dadurch wird der potentielle Markteintritt von neuen Wettbewerbern ermöglicht, wenngleich ein Markteintritt im Idealfall nicht erfolgen wird, da die bestehenden Betreiber durch niedrige Transaktionspreise und hohe Innovationskraft diesen verhindern. Der Regulierer muss in einer solchen Industriekonfiguration lediglich die *Contestability* des Marktes gewährleisten, in dem er für offene Kommunikationsstandards sorgt. Damit wird ihm zwar eine wichtige, aber dennoch beschränkte Rolle zugewiesen, so dass sich Effizienzverluste aufgrund zu großer Bürokratie in Grenzen halten sollten.

Inhalt des dritten Kapitels Die zweite Frage nach dem Einfluss der Corporate Governance auf die Wettbewerbsfähigkeit von Börsen wird in Kapitel 3 beantwortet, welches auf dem Arbeitspapier mit dem Titel 'Demutualization, Outsider Ownership and Stock Exchange Performance - Empirical Evidence' basiert.[7] Hierbei wird anhand eines selbst gesammelten Datensatzes von 28 Börsen für die Jahre 1999-2003 der Einfluss verschiedener Governancestrukturen auf die operative Effizienz und Faktorproduktivität untersucht. Motivation hierfür ist, dass sich Börsen laut einer Umfrage von Scullion (2001) durch die Restrukturierung in ein

[7] Dieses Papier ist in der Working Paper Reihe Finance und Accounting Nr. 157 der Universität Frankfurt erschienen, sowie auf drei wissenschaftlichen Konferenzen vorgetragen worden (Paris International Meeting on Finance, 2005, Workshop on Law and Economics, Bocconi Universität, Mailand, 2006 und European Financial Management Association, Madrid, 2006). Die aktuelle Fassung entspricht weitgehend der im November 2005 in der Zeitschrift *Economics of Governance* eingereichten Version.

gewinnorientiertes Unternehmen eine verbesserte Wettbewerbsfähigkeit erhoffen, die sich unter anderem in erhöhter operativer Effizienz und Faktorproduktivität widerspiegeln sollte.

Ein wesentlicher Punkt, der dabei explizit analysiert wird, ist, inwieweit ein Börsengang zu einer Verbesserung der Effizienz führt. Dies ist vor dem Hintergrund zu sehen, dass zahlreiche Börsen zwar eine Demutualization im Sinne einer Umwandlung in ein gewinnorientiertes, aktionärsbasiertes Unternehmen durchgeführt, jedoch die bestehenden Mitglieder als Eigentümer behalten haben. Andere Börsenbetreiber veränderten hingegen die Eigentümerstrukturen durch ein Listing nachhaltig, indem sie ihre Anteile an (Outside) Investoren verkauften, die keine geschäftlichen Beziehungen mit den Börsen unterhalten. Manche Industrieexperten sehen das 'going public' als notwendige Bedingung, um eine höhere operative Effizienz zu gewährleisten.[8] Die Vorteile eines Börsenganges sollten demnach die zusätzlichen Kosten überwiegen, die durch Ausgaben für die Neuemission sowie durch strengere Veröffentlichungspflichten entstehen. Aus diesem Grund ist es von ökonomischer Relevanz, inwieweit gelistete Börsen tatsächlich einen zusätzlichen Effizienzgewinn gegenüber demutualisierten Börsen erzielen, die keinen Börsengang vorgenommen haben.

Um diese Fragestellung empirisch beantworten zu können, wird in einem ersten Schritt eine nicht-parametrische Effizienz- und Faktorproduktivitätsmessung mittels *Data Envelopment Analysis* (DEA) vorgenommen. Durch die Verwendung von linearen Programmen können hierdurch Effizienzwerte von Multi-Input, Multi-Output-Unternehmen errechnet werden. Dieses gegenüber eindimensionalen Output-zu-Input-Quotienten vergleichsweise aufwändige Verfahren ist notwendig, um ein möglichst realistisches Abbild der Produktionsfunktion von Börsen zu erhalten. Dies liegt darin begründet, dass die Plattformbetreiber eine unterschiedliche Anzahl von Aktivitäten verfolgen. Eine Konzentration auf einen bestimmten Output würde somit diejenigen Börsen benachteiligen, die einen stärkeren Fokus auf nicht berücksichtigte Outputs legen, weil es meist nicht möglich ist, eine entsprechende Anpassung der Inputseite vorzunehmen.

In einem zweiten Schritt werden die ermittelten Effizienz- und Faktorproduktivitätswerte als abhängige Variablen in Regressionsanalysen eingesetzt, um den Einfluss von bestimmten Faktoren zu messen, die zwar nicht unmittelbar mit den Produktionsprozessen der Börsen zusammenhängen, sich jedoch auf ihre operative Effizienz auswirken können. Es wurden vier Bereiche identifiziert, die hierbei relevant sein könnten: Während der Wettbewerbsdruck, die finanzielle Flexibilität und die verschiedenen Geschäftsmodelle der Börsen als Kontrollvariablen in die Regression einfließen, ist der Einfluss des vierten Bereiches, die Organisationsform der Börsen, der Hauptfokus des Artikels. Hierbei wird zwischen Börsen unterschieden, die (1) als Genossenschaft (oder als staatliches Institut) organisiert sind, (2) Handelsplattformen, die eine Demutualization durchgeführt haben, jedoch nach wie vor im Besitz ihrer Mitglieder sind, und (3) solchen, die mittels eines Börsengangs hauptsächlich über (Outside) Investoren als Aktionäre verfügen.

Die Ergebnisse bestätigen, dass Börsen, die eine Demutualization durchgeführt haben, über eine höhere operative Effizienz verfügen. Allerdings schneiden sie gegenüber Genossenschaftsbörsen in der Faktorproduktivitätsanalyse schwächer ab. Eine mögliche Erklärung hierfür ist, dass durch die Restrukturierungsmaßnahmen in der Organisationsform auch bestehende Aktivitäten modifiziert wurden und somit einer (temporären) operationellen Friktion unterlagen. Eine weitergehende Analyse zeigt in der Tat, dass die Variabilität der Inputvariablen bei den Börsen am höchsten ist, die während der Betrachtungsperiode ihre Governancestruktur änderten. Daher ist zu vermuten, dass eine Restrukturierung zu erhöhten operativen Ineffizienzen führt. Eine weitere wesentliche Erkenntnis des Beitrages ist, dass gelistete Börsen keine signifikant

[8] Vergleiche zum Beispiel OECD (2003) oder Scullion (2001).

höhere Effizienz als demutualisierte, nicht gelistete Unternehmen besitzen. Daher erscheint es als wahrscheinlich, dass die Börsengänge nicht aufgrund der zu realisierenden operativen Effizienzgewinne durchgeführt wurden, sondern als mögliche Exit-Option für diejenigen Mitglieder einer Börse genutzt wurden, die eine Modernisierung der Börse finanziell und strategisch nicht mittragen wollten.

Inhalt des vierten Kapitels Die Frage 3 nach dem Investitionsverhalten von Börsen und den Motiven zur Demutualization wird in Kapitel 4 behandelt, welches das Arbeitspapier mit dem Titel 'Investment Behavior of Stock Exchanges and the Rationale for Demutualization - Theory and Empirical Evidence' beinhaltet und in Koautorenschaft mit Marcel Tyrell entstanden ist.[9]

Im theoretischen Teil wird zunächst mit Hilfe eines statischen *Global Games* Modells das Investitionsverhalten von zwei Börsen mit unterschiedlicher Governancestruktur analysiert, die im Wettbewerb um einen Teil k des Handelsvolumens $v + k$ ihrer Mitglieder stehen. Hierbei werden Investitionen mit fixen Kosten betrachtet, die über eine Transaktionsgebühr finanziert werden und nur dann wertsteigernd für die Mitglieder sind, wenn ein bestimmtes Handelsvolumen auf der Plattform vorhanden ist. Das Basismodell ergibt, dass die Investitionsneigung einer von Investoren kontrollierten, gewinnorientierten Börse im Vergleich zu einer genossenschaftlich organisierten Plattform höher ist, da letztere sich ex ante nicht an ein bestimmtes Transaktionsgebührenniveau binden kann. Dies liegt darin begründet, dass die genossenschaftliche Börse über keine wesentlichen finanziellen Puffer in Form von Eigenkapital verfügt und somit die gesamten Kosten der Investition in jedem Fall von den Mitgliedern getragen werden müssen. Bei gewinnorientierten Börsen hingegen existieren externe Eigenkapitalgeber, die für eventuelle Verluste aus der Investition aufkommen, sodass hier das *Commitment*-Problem nicht existiert. Dies führt in der Folge dazu, dass die Mitglieder der genossenschaftlichen Börse, wenn sie beabsichtigt zu investieren, das Handelsvolumen k auf die gewinnorientierte Plattform transferieren, weil sie sonst - analog zu einem *Bank-Run*[10] - befürchten müssten, die Kosten der Investition alleine zu tragen. Dies wird die genossenschaftliche Börse antizipieren und in der Konsequenz geringere Anreize besitzen, in das Projekt zu investieren. Hingegen erhält die gewinnorientierte Börse durch diesen Umstand noch zusätzliche Anreize in das Projekt zu investieren, da sie neben dem Handelsvolumen ihrer eigenen Mitglieder nun auch mit der Liquidität der Mitglieder der konkurrierenden Börse rechnen kann und somit die Vorteilhaftigkeit des Projektes ceteris paribus weiter steigt. Da jedoch die wechselwilligen Mitglieder der Genossenschaftsbörse befürchten müssen, dass die gewinnorientierte Börse die Effizienzgewinne nicht an sie weitergeben wird und stattdessen die Renten der Investition für sich selbst verbucht, wird dies unter bestimmten Bedingungen doch zu einer Investition an der eigenen Börse führen, um durch eine *Second-Sourcing* Taktik eine bessere Verhandlungsposition gegenüber der gewinnorientierten Börse in der Gebührenfestsetzung zu erzielen. Dieser Effekt ist dabei positiv mit dem Anteil des Handelsvolumens $\frac{k}{v}$ korreliert, der zwischen den Börsen transferiert werden kann.

Das Grundmodell nimmt zunächst eine gleichmäßige Verteilung der aus der Investition generierten Renten auf die Mitglieder an. Dies bedeutet, dass das Projekt als Investition in das Kerngeschäft der Börse interpretiert wird, wie es zum Beispiel bei einer Modernisierung der Handelsplattform und den damit verbundenen Einsparungen pro gehandelte Transaktion denkbar wäre. In einer Erweiterung wird zudem der Fall einer ungleichmäßigen Distribution der Renten betrachtet. Empirisch gesehen könnten dies Investitionsvorhaben in verwandte Geschäftsbereiche

[9]Dieser Beitrag ist während eines gemeinsamen Forschungsaufenthalts an der Wharton School, University of Pennsylvania, Philadelphia entstanden. Er ist kürzlich für die 13. Tagung der Deutschen Gesellschaft für Finanzwirtschaft (DGF) angenommen worden.

[10]Siehe hierzu Diamond und Dybvig (1983)

wie Derivatehandel, Wertpapierabwicklung oder Systemsoftwarevertrieb sein, die nicht für alle Mitglieder in gleichem Maße vorteilhaft sind. So wird beispielsweise eine auf Aktien spezialisierte Kursmaklerin nur einen geringen Nutzen von einer Investition in den Derivatehandel oder in die Softwareentwicklung haben, jedoch müsste sie die Kosten in Form von höheren Transaktionskosten mittragen. Ein großes Wertpapierhaus, das zahlreiche Aktivitäten abdeckt, hingegen könnte die Vorteile aus dieser Investition einfacher internalisieren und wäre somit ein Profiteur dieser Investition. In einer Konstellation, in der die Mehrheit der Mitglieder eine negative Externalität durch die Investition befürchten muss, werden die Ergebnisse des Grundmodells, d.h. die höhere Investitionsneigung einer (Outside) investorendominierten Börse, weiter verstärkt, da sie die Mitglieder der Genossenschaftsbörse mit positiver Externalität zu einer für sie vorteilhafteren Gebührenstruktur abwerben kann. Falls eine Mehrheit der Mitglieder jedoch eine positive Externalität von dieser Investition erhält, ist die Investitionsneigung der Genossenschaftsbörse sowie der investorenorientierten Börse für niedrige $\frac{k}{v}$-Werte gleich. Erst wenn k im Vergleich zu v groß ist, besitzt eine Genossenschaftsbörse geringere Investitionsanreize, da die Vorteile aus dem Second-Sourcing von den hohen Kosten der Investition an der eigenen Börse übertroffen werden.

In einem weiteren Schritt wird ein dynamisches *Overlapping-Generations* Modell betrachtet, um die Überlebensfähigkeit von genossenschaftlich organisierten Börsen zu analysieren, wenn sie im Wettbewerb mit gewinnorientierten Plattformen stehen. Dabei wird angenommen, dass jede Generation von Mitgliedern genau zwei Perioden lebt und die jeweils junge Generation darüber entscheidet, ob sie ihr Handelsvolumen auf die angestammte, genossenschaftlich organisierte Börse transferiert oder alternativ ein Angebot einer gewinnorientierten Börse annimmt und somit die genossenschaftliche Börse in der Folgeperiode 'aussterben' lässt. Es wird gezeigt, dass eine genossenschaftliche Börse nicht mit einer gewinnorientierten Handelsplattform konkurrieren kann. Des Weiteren wird bewiesen, dass sie - falls sie sich ebenfalls in eine gewinnorientierte Börse konvertiert - den Wettbewerb überstehen wird. Aus den beiden Ergebnissen kann somit der in der Empirie beobachtbare Umstand erklärt werden, dass traditionelle Börsen, die nicht über moderne Handelssysteme und wettbewerbsfähige Gebühren verfügen, sukzessive an Liquidität gegenüber gewinnorientierten Handelsplattformen verlieren und dass die Demutualization oftmals der einzige Ausweg ist, ihr Überleben zu sichern.

Im empirischen Teil des Artikels werden zwei Hypothesen entwickelt, die auf den Ergebnissen der theoretischen Modelle basieren. Zum einen wird mit einem leicht verkleinerten Datensatz, der auch in den empirischen Untersuchungen der Kapitel drei und fünf zur Anwendung kommt, überprüft, ob die Wahrscheinlichkeit einer Demutualization mit steigendem Wettbewerbsdruck steigt. Zum anderen wird verifiziert, ob die Investitionsneigung von Börsen tatsächlich steigt, wenn sie von (Outside) Investoren kontrolliert werden. Für beide Fragestellungen werden Probit-Regressionen verwendet, da die abhängigen Variablen jeweils dichotomer Natur sind. Um sicherzustellen, dass keine Verzerrungen bei der Schätzung der Wettbewerbs- und Governancekoeffizienten durch korrelierte Fehlerterme entstehen, werden die beiden Probit-Modelle simultan geschätzt. Die Ergebnisse bestätigen die Hypothesen auf statistisch hochsignifikantem Niveau.

Inhalt des fünften Kapitels Die vierte Frage nach der Effizienz und Faktorproduktivität von verschiedenen Geschäftsmodellen wird im fünften und letzten Kapitel der Dissertation analysiert und verwendet dabei die Ausführungen des Arbeitspapiers mit dem Titel 'Stock Exchange Business Models and Their Operative Performance'.[11] Der Beitrag untersucht em-

[11] Dieses Papier ist in einer Vorversion in der Working Paper Reihe Finance und Accounting Nr. 158 der Universität Frankfurt erschienen, sowie auf einer Konferenz vorgetragen worden ('Clearing and settlement of financial markets: Europe and beyond', Cass Business School, London, 2005). Die aktuelle Fassung ist für die

pirisch, inwieweit verschiedene Geschäftsmodelle, wie etwa die Integration von Derivatehandel, Wertpapierabwicklung oder Softwareentwicklung und -vertrieb sich auf die operative Effizienz und Faktorproduktivität von Börsen auswirken. Die Analyse leistet damit einen empirischen Beitrag zur Diskussion über horizontale und vertikale Integrationskonzepte im Börsensektor, die von zahlreichen europäischen Marktteilnehmern und der EU-Kommission intensiv geführt wird. Zwar werden in diesem Artikel keine gesamtwohlfahrtlichen Effekte gemessen, jedoch sind Aussagen über die operative Effizienz von verschiedenen Geschäftsmodellen der erste Ansatzpunkt, um best-practice Geschäftsmodelle zu identifizieren, die am kostengünstigsten arbeiten können.[12]

Die hierbei verwendete Methodik entspricht weitgehend der Vorgehensweise aus Kapitel drei: Zunächst werden mittels DEA die technische Effizienz und Faktorproduktivität ermittelt. Anschließend werden diese Ergebnisse auf verschiedene Geschäftsmodelle regressiert, wobei weiterhin für andere Faktoren wie Governance, Wettbewerbsdruck und finanzielle Flexibilität kontrolliert wird. Die Ergebnisse zeigen, dass die Effizienz von horizontal oder vertikal integrierten Börsen nicht höher ist als bei solchen, die sich ausschließlich auf den Kassamarkthandel konzentrieren. Unter gewissen technologischen Annahmen über die Produktionstechnologie (*Variable-Returns-to-Scale*) schneiden sie sogar signifikant schlechter ab. Allerdings scheint die Faktorproduktivität bei vertikal sowie bei horizontal *und* vertikal integrierten Börsen signifikant höher als bei fokussierten Börsen auszufallen. Die Untersuchung bietet somit keine eindeutige Indikation zur Unterstützung horizontaler oder vertikaler Geschäftsmodelle.

zweite Runde des Review-Prozesses im *Journal of Banking and Finance* eingereicht worden.

[12] Inwieweit ein technisch effizientes Geschäftsmodell auch zu einer Verringerung der Transaktionskosten führt, hängt allerdings von weiteren Faktoren wie der Governance der Börsen und dem Wettbewerb ab.

Chapter 2

Settling for Efficiency - A Framework for the European Union *

*This is a slightly revised version of the book chapter 'The European Securities Transaction Industry', which is forthcoming in *Efficient Organizational Design - Balancing Incentives and Power* by Marco Weiß. We thank Reinhard H. Schmidt, Marcel Tyrell and Ingo Walter for their comments. We appreciate discussions with Stefan Mai and Andreas Wolf of Deutsche Börse Group.

2.1 Introduction

Despite a lot of re-structuring and many innovations in recent years, the securities transaction industry in the European Union is still a highly inefficient and inconsistently configured system for cross-border transactions. Many EU politicians eagerly promote the completion of the Single European Market, but - few exceptions aside - the industry structure still resembles closely the former fragmented market structure of largely independent organizations operating along national lines. This causes higher costs in the handling of cross-border securities[1] which ultimately translates into higher costs of capital - a significant competitive disadvantage for European firms compared to companies in the USA.

Industry experts point at several aspects that impede the realization of an efficient securities transaction system. While trading is widely seen as efficient, clearing and settlement processes across different countries are still too costly. The fragmented industry structure which does not allow for capturing the significant benefits from scale, scope, and network effects is paralyzed by several obstacles to consolidation. Besides political, cultural, and legal barriers among the different countries, the motives of the market participants such as infrastructure providers and direct users sometimes contribute to the impediment of consolidation efforts and thus prevent a socially optimal solution.

What has become increasingly visible is the lack of a common communication standard among service providers. This could be a result of vertically integrated providers with incompatible information dissemination standards and post-trading routines. As a consequence, the typical cross-border trade requires substantial interaction among the pertaining different trading, clearing, and settlement systems which can only be effectively dealt with by additional intermediaries such as (sub)custodians. This extends the length of the value chain and thereby increases the costs for the investors. More interaction requirements are also more risky due to the higher complexity of the trade and a higher likelihood of failures. Higher risks usually mean additional collateral requirements, which is a further cost driver.

Not surprisingly, there are diverging opinions on how to cope with the current inefficiencies. Don Cruickshank, former CEO of the London Stock Exchange, favors a market structure that separates trading from post-trading activities, while the latter should be organized as a utility comparable to the Depository Trust & Clearing Corporation (DTCC) in the USA:

> *"If the single market in financial services is to be delivered, then competition and regulatory policies must be allowed to work side by side. [...] We can see [that] some spring shoots of such an approach is in moves to allow exchanges to compete on a harmonised utility clearing and settlement layer as the most effective way of reducing transaction costs in the securities industry as a whole and maximising the potential for competition elsewhere in the securities value chain."*[2]

This stands in strong contrast to Werner Seifert's view, former CEO of Deutsche Börse, who claims that an efficient solution can be delivered by vertical integration of the activities and that the culprit are the myriads of different regulators in the EU:

> *"Many people claim that clearing and settlement should be done by a single, Europe-wide utility, like in the US, and that greedy private operators help themselves from the till by insisting that trading, clearing, and settlement remain integrated. Not*

[1] Lannoo and Levin (2001, p. 14 - 30) and Deutsche Börse Group and Clearstream International (2002, p. 15 - 29) present a cost analysis of cross-border transactions.

[2] Cruickshank (2003).

> *so! At Deutsche Börse we have looked at this very closely, and the overwhelming problem in the integration of European capital markets is driven by different regulations, even different applications of identical rules where they exist - the whole messy business of EU regulation, with actual implementation left to the member states."*[3]

What these two views reveal is that different and sometimes intertwined forces are at play in the European securities transaction industry. The motives of the different opponents can be biased by strategic deliberations and the desire to advance the industry structure to the own advantage. This paper sheds some light on these opposing claims by applying economic tools to identify the underlying economies in the industry and to comment on an efficient securities transaction system for the European Union. Our contribution is to provide a framework for the analysis of this industry which identifies and structures the different elements, interprets efficiency in a broader sense, and offers policy advice by proposing consistently configured trading, clearing, and settlement systems (TCS-systems) that achieve high levels of efficiency from the perspective of a benevolent organizational designer. Applying the methodology of system theory, we give answers to the following questions: (1)What are economic characteristics of the relevant activities, and which constituencies are involved in these activities? (2) Which strategic decisions can be conducted by the industry players, and what are the consequences thereof? (3) What are consistently configured organizational designs that provide superior efficiency to alternative set-ups?

Our framework presents three systems for the European securities transaction industry that are configured in a consistent way: The first assigns a prominent role towards regulation and allows to capture the economies in the industry to a great extent by integrating and consolidating the different activities in the different national markets. The second lets the market forces work and - although more fragmented - allows for high innovation and dynamics in the industry. The third consistent system is characterized by consolidation and integration as well, but instead of heavy regulation it is kept open to market forces by adjusting the necessary elements, so that any ensuing monopoly remains contestable. We conclude that the third design has its advantages over the other two: Policy makers in the European Union should strive to implement the various elements of it to a consistent whole to the benefit of the European capital market.

Related literature Public authorities and academics alike have taken an interest in the European securities transaction industry. Different regulatory bodies and committees established by the European Commission mainly focus on the identification of structural weaknesses of the industry and outline concrete recommendations to overcome these problems: In response to ECOFIN's request to give regulatory proposals for the European Securities Markets in 2001, the Committee of Wise Men, chaired by Alexandre Lamfalussy, demands a further restructuring and a scrutiny for the requirement of a regulatory framework in the clearing and settlement area. Furthermore, they point at competitive issues and general systemic risk aspects that may evolve in the context of monetary policy and the functioning of payment systems.[4] The Giovannini Group, a consultative group headed by Alberto Giovannini and appointed by the European Commission, analyzes the cross-border clearing and settlement arrangements in the EU and finds that international transactions are more complex and costly than domestic transactions due to fifteen barriers and that these inefficiencies represent a paramount barrier to

[3]Seifert (2003, p. 82).
[4]See Lamfalussy (2001).

integrated financial markets.[5]

The European Shadow Financial Regulatory Committee (ESFRC) disagrees to the claim of some market participants that a forced consolidation into a pan-European regulated utility would solve these problems. Instead, they pledge for an ownership separation between trading and post-trading facilities in order to foster fair competition.[6] The Committee on Payment and Settlement Systems (CPSS) and the Technical Committee of the International Organization of Securities Commissions (IOSCO) jointly developed recommendations for securities settlement systems that aim to improve the safety and efficiency of these systems. In particular, the report recommends minimum requirements that these systems should be obliged to fulfil and the best practices that they should strive for.[7] Based on these recommendations, the Committee of European Securities Regulators (CESR) and the European Central Bank (ECB) published 19 standards[8] which also incorporated comments on standardization, communication and messaging, and business continuity[9] as well as on standards for risk management controls[10]. Market participants were consulted on draft versions, and many institutions used their chance to respond. Some organizations also published their own reports and white papers on the industry.[11]

Academic papers usually highlight particular aspects of the industry by focusing on a certain aspect in the securities transaction value chain, while inevitably neglecting other potentially interrelated factors. Some contributions provide empirical research on the main activities: Malkamäki and Hasan (2001) investigate potential economies of scale and scope at stock exchanges, while Schmiedel, Malkamäki, and Tarkka (2006) focus on the same subject in the case of settlement systems. A related study was conducted on network effects at exchanges by Schmiedel and Hasan (2003). Additionally, formal models are presented for various topics such as on the economics of financial networks by Economides (1993), on vertical integration by Köppl and Monnet (2003) and Tapking and Yang (2004), on competition between central securities depositories (CSD) by Kauko (2003), and on competition between custodians and CSDs by Holthausen and Tapking (2003). Furthermore, moral hazard aspects were modeled to distinguish between net and gross settlement by Kahn, McAndrews, and Roberds (2003).

There are, however, also contributions that apply a more holistic approach and thus are closer related to the framework used in this paper. One of the first academic contributions is by Giddy, Saunders, and Walter (1996): They analyze four alternative models for the European clearing and settlement market mainly from the perspective of the users of these services. Differences between their models exist in the way the linkages between the CSDs are structured. Our approach is similar to theirs in respect to evaluating trading, clearing, and settlement along three dimensions and deriving distinct organizational designs for a future industry setting. Unlike their approach, we take microeconomic incentives of the key industry players in more detail into account and base the analysis of possible systems on sounder foundations regarding these aspects.

The paper by Milne (2002) establishes analogies between other utility network industries, such as the telecommunication sector, and the securities settlement market. These markets, he argues, have similarities in possessing a natural monopoly that has to be regulated. Milne

[5]See Giovannini Group (2001) and Giovannini Group (2003) for details on these barriers in different areas.

[6]See European Shadow Financial Regulatory Committee (2001).

[7]See Committee on Payment and Settlement Systems and International Organization of Securities Commissions (2001).

[8]See Committee of European Securities Regulators and European Central Bank (2004).

[9]These issues were particularly raised by the G30, an international body composed of senior figures from the private and public sectors and academia.

[10]The European Association of Central Counterparty Clearing Houses (EACH) was one of the initiators of this point.

[11]See, for example, the White Paper by Deutsche Börse Group (2005) which describes the post-trade market.

identifies the book-entry function and the transmission of corporate actions as the two activities of the value chain that need to be regulated via access pricing and the establishment of common communication standards. He concludes that this minimal regulatory effort should suffice to create a level playing field on all other stages such as clearing, settlement, and custody, rendering further public interventions unnecessary. While we agree on this notion, we extent his policy advice by presenting and applying a more comprehensive framework that - together with the methodology of system theory - allows a broader policy advice.

The paper closest to ours in spirit and result is by van Cayseele (2004) who agrees with our reasoning proposed in a previously published working paper version of this paper[12]. Van Cayseele starts from the same premises, asking what an economically optimal outcome for the clearing and settlement industry would be. Relying on the concepts of 'essential facilities' and of 'two-sided markets'[13], he concludes that the advantage of a market solution relying on contestability of the industry is to be preferred over a single regulated monopoly with the potential costs of government failure.

Outline Section 2.2 briefly describes the three efficiency concepts deployed in this paper. We concentrate on the activities of trading, clearing, and settlement along the value chain and the providing institutions.[14] We explain the underlying economies of the activities at each level of the value chain and the interdependencies across the whole chain in Section 2.3. The role of regulators is briefly discussed as well. Section 2.4 regards possible strategies and associated actions to highlight the microeconomic incentives of the infrastructure providers. Three important decisions about the configuration of the design have to be made - where to set the boundaries, whether to adopt an industry-wide standard, and how to assign ownership rights. We show consistent TCS-systems in Section 2.5 that are efficient from the viewpoint of social welfare. Its individual components are complementary and thus reinforcing each other. Potential drawbacks and implications for social welfare are discussed. Section 2.6 concludes with a comparative organizational analysis.

2.2 Three concepts for evaluation

Economic rents are created through 'good' investment decisions by the various constituencies and allocated to them through 'good' distribution rules. This interplay between ex ante incentives and ex post distribution determines also the efficiency of possible TCS-systems. We analyze efficiency along the three lines of static, dynamic, and systemic efficiency to evaluate the generated economic rents and estimate the resulting overall efficiency. We shortly describe each concept and potential trade-offs between them.

Static efficiency A certain activity is performed in a statically efficient way if there is no solution that would allow a less costly implementation. It is under this notion that the commonly used concept of cost efficiency is considered. Parameters influencing the static efficiency are the costs of production which in turn are influenced by the underlying technologies and the

[12] See Serifsoy and Weiß (2003).

[13] See also Rochet and Tirole (2003).

[14] Custody functions follow the settlement process. These ensue the distribution of coupon payments, the implementation of corporate actions and the lending of securities besides the trading-induced transfer of ownership. We will subsume these transaction-induced custody aspects under the settlement activity and ignore the other services in custody. Taking into account all aspects of custody would add to the complexity, while providing only limited value-added for our purposes.

economies arising from them. In the securities transaction industry, network externalities[15] are prevalent. They lead in many areas, like the trading of a single derivative instrument or the settlement of a particular stock, to an efficient market structure that is a natural monopoly.

Static efficiency generally increases if the number of companies conducting business along the securities transaction value chain decreases due to the underlying economies. The costs of any regulation that has to be set up to keep the remaining companies and their rent-extracting potential in check, however, lead to a lowering of static efficiency.

Dynamic efficiency Activities are performed in a dynamically efficient way if today's structures and investments do not hamper the efficient performance of these activities in the future. By investing in a certain technology or by institutionalizing a certain industry structure, the ability to change and to adapt becomes affected. Particularly the dominance by a network provider may have detrimental effects on the innovativeness of the market.[16] Industry structures and processes that do not allow for innovation and for quality improvement in future thus are not efficient under the notion of dynamic efficiency. Competition in the market usually helps to alleviate problems such as low innovativeness or poor quality of the goods and services. The absence of competition may lead to complacency and to less innovation as it is common in a monopolistic environment. For estimating dynamic efficiency, key parameters are (1) the industry structure that determines the difficulty of entering the TCS-industry, (2) the rate of technological innovation, and (3) the propensity of all constituencies to invest and the resulting sum of all investments.

Systemic efficiency Our third evaluation concept, denoted systemic efficiency, provides insight on systemic risk issues that are inherent on various stages of the value chain and takes into account the stability of the TCS-industry when faced with adverse systemic events. We define systemic efficiency as the degree of robustness of the activities in the securities transaction industry to systemic risks that are borne from strong adverse systemic events.[17] A systemic event occurs when a 'bad event' for one or more market participant(s) has subsequent negative repercussions on other market participants. Such an event may vary in severity, ranging from a delay in payment or delivery of the securities in question to a full-blown failure of a party to meet the agreed-upon obligations. Potential contagion effects have to be taken seriously most notably in cases of strong negative systemic events like a failure of an institution. Systemic risk issues are treated with great care by public and private entities. Both ex ante (crisis prevention) and ex post (crisis management) measures have to be introduced in order to deal with systemic risks. Appropriate regulation has to ensure this.

Interdependencies Note that the three concepts of efficiency are interdependent: (1) The statically efficient solution of a monopoly conveys only minor incentives to innovate, whereas a few players in an oligopoly can interact in heavy competition and try to develop better products and processes thereby increasing dynamic efficiency. They also compete for monopoly rents that are non-existent in a perfect-competition-environment where the users of the infrastructure reap the main part of economic rents. The potential profit that can be gained is, therefore, a big enough incentive to undertake the large technological investments needed up-front. (2) Static efficiency can decline when measures are taken to increase systemic efficiency: The provision of

[15] For a detailed discussion on network externalities confer Shapiro and Varian (1999, p. 173 - 225).

[16] See Economides (1993, p. 92).

[17] The terminology used is adapted from de Bandt and Hartmann (2000) albeit the authors discuss this issue in much greater depth. See de Bandt and Hartmann (2000, p. 10 - 17) for further details.

collateral, for example, increases the stability of the industry against adverse shocks but levies opportunity costs on the market participants. The existence of economic rents also facilitates the build-up of a financial buffer that allows these companies to be more stable in times of systemic crises. (3) Perfect competition would contribute potentially more in terms of innovativeness thereby increasing dynamic efficiency but the systemic efficiency could be damaged: A more fragmented structure may impose more work on regulators to keep the overall system sound. However, competition also fosters innovations in risk management tools which are beneficial to systemic efficiency.

2.3 The securities transaction industry

To analyze the securities transaction industry we define the securities transaction value chain and the constituencies that are involved in these activities. The value chain has three main activities: Securities need to be traded, the results of the trade have to be confirmed and calculated by a clearing process, and the delivery of money and paper to the parties to a trade has to be settled. Institutions like exchanges, clearing houses, and central securities depositories (CSD) provide these services. Two more constituencies are involved in the value chain, namely the users and regulators. The users are the clients of the infrastructure provider and can be further broken down into banks and brokers as direct users[18] and investors and issuers as indirect users. The regulators monitor the processes in the industry to ensure a sound and efficient transaction environment. Their appropriate role is discussed at the end of this section.

2.3.1 Economies of the securities transaction value chain

Network effects There exist strong positive network externalities on each of the three stages: In trading, network effects can be both observed on the investors' as well as on the issuers' side. For the former, becoming a member of an already large network of investors that trade on the same platform increases both her own and the other's utility by providing additional liquidity to the market.[19] The latter group benefits from larger networks as these can absorb the issuers' need for capital more easily.

There are viable positive network externalities on the user side for both clearing and settlement. A concentration on few transaction systems allows for a higher proportion of clearing and settlement instructions to be processed internally. This increases the utility of all users because costly links to other networks become less necessary. In the extreme, a single clearing and settlement network would be faster and less costly in comparison to processes which require the interaction with several clearing and settlement systems.

Economies of scale The providers of trading, clearing, and settlement facilities can reap significant economies of scale as the setup costs for a transaction platform have a substantial portion of fixed costs, so that average costs fall with increasing transaction volume. This view

[18]Banks and brokers are the main institutions using the infrastructure as the immediate users. They play a pivotal role in the securities transaction value chain for institutional as well as retail investors on the one side and for companies with their underwriting business on the other side. By internalizing security transactions and by acting as subcustodians, banks are to a certain degree also direct competitors of the infrastructure providers. A model on the competitive relationship between CSDs and custodians can be found in Holthausen and Tapking (2003).

[19]The pivotal role of liquidity stems from the potentially large costs that can arise from illiquidity during trading. According to Deutsche Börse Group and Clearstream International (2002, p. 17 - 22) their proportion of total trading costs is substantial. Liquidity can be characterized along four dimensions, namely width, depth, immediacy, and resilience. See Harris (1991, p. 3). For a model of such two-sided markets see Rochet and Tirole (2003).

is confirmed by empirical investigations. Malkamäki's analysis on the processing of trades at stock exchanges shows scale economies for increasing trading volume.[20] Another contribution by Schmiedel, Malkamäki, and Tarkka (2006) measured significant economies of scale for settlement systems: Platforms with high transaction volumes will be able to offer lower transaction costs to users than low-volume competitors. For non-automated transaction systems, i.e. floor-based trading, this effect is not as pronounced as for automated trading systems, since the ratio of fixed costs to variable costs is higher for the computerized system.

Economies of scale are also present in counterparty risk management. Especially if a central counterparty (CCP) is used in the clearing stage, the users of the facility can save resources on the management and control of counterparty risks. By pooling risk management facilities at the CCP, costs can be eliminated by risk management specialization effects. Additionally, if netting mechanisms are used, the users will enjoy reduced capital provision requirements and, therefore, lower opportunity costs.[21] As a consequence, scale economies may be even more pronounced in clearing than in other stages.

Economies of scope All three activities exhibit also potential economies of scope. Providers are able to process different types of securities on the same platform, while incurring only relatively low incremental costs. Clearing facilities that process different classes of securities such as stocks, bonds, and derivatives have additional leeway for scope economies as they are able to implement innovative risk management procedures such as cross-collateralizing with different securities classes. This would lead to an overall decrease in capital provision requirements to the users and would consequently save costs.

The upshot of the results above suggests a tendency towards a strong concentration of the activities or even a natural monopoly on each stage of the value chain due to the underlying and mutually reinforcing economies. According to our definition in section 2.2, a concentration in the industry translates into high static efficiency.

Contestability of the market A concentrated market in turn lowers dynamic efficiency as the latter falls with decreasing levels of competition. The existence of substantial network externalities or scale and scope economies creates a barrier to entry and offers established platforms some protection from competitors.[22] Nevertheless, high levels of dynamic efficiency can be achieved if the market for securities transactions remains contestable, i.e. if competitive and innovative infrastructure providers can gain market share at the expense of established competitors.

The diversion of transaction volume from an incumbent provider is the more likely the more of the following aspects coincide: (1) The competitor demands lower fees. Domowitz and Steil (1999, p. 8 - 9) give several examples of this behavior. (2) A competing provider offers a significantly better service for users based on a better technology which may manifest itself in faster, more reliable or more convenient transaction handling. (3) The competitor offers new products or services which have not been supplied and 'monopolized' by an established provider yet. (4) Clearing and settlement institutions reduce their capital provision requirements by introducing netting processes. However, this point may be a matter of regulatory concern as competing institutions might want to apply less stringent risk management procedures to successfully underbid the fee structure of competitors.

[20] However, he confines his findings for very large stock exchanges. See Malkamäki (1999) for further details.

[21] See Van Cauwenberge (2003, p. 94).

[22] This view is shared by Economides (1993, p. 92 - 93). He states that, as a consequence of the reinforcing nature, a financial "network exhibits positive critical mass". A further consequence of networks "is that history matters [...] because of significant switching costs" which protect established players in the market.

Systemic risk issues Systemic efficiency is particularly relevant in the clearing and settlement of securities and appendant funds. There are several sources of and alleviation efforts to systemic risks. Clearing and settlement institutions have developed risk management tools that attempt to reduce both ex ante and ex post the various types of settlement risk. Since the various types of systemic risks, such as counterparty, custody, and cross-border risks, have been elaborated in detail by other contributors[23] we focus on the relationship between systemic efficiency and market concentration. The relationship is not straight-forward. Both a fragmented and a consolidated industry structure have to deal with trade-offs.

A concentrated industry structure can exploit economies in centralizing risk management efforts as it is more cost efficient to have one party collect the information and to monitor the other parties instead of having all parties monitoring each other. Thus, a central risk manager will be more cost efficient and more sophisticated. However, the central risk manager may bank too strongly on its dominant position and believe that public entities would bail him out in case of a failure. Moral hazard may materialize in the form of reduced monitoring efforts.[24] Therefore, regulatory effort - albeit rather easy as only one institution has to be controlled - might be necessary.[25] Additionally, a higher degree of consolidation leads to less complexity in the interaction between the providers and thus reduces the probability of failures in communication and asset transfers.

A fragmented industry structure on the other hand may provide systemic efficiency that is superior to a concentrated market. More industry players will usually lead to higher levels of competition. A possible parameter of competition can be the provision of sound and stable transaction systems among providers which boosts systemic efficiency. Another positive aspect of fragmentation is the existence of redundancies which - if communication protocols between different transaction systems are compatible - can be used to re-route transactions from a failed to an intact system. Multiple transaction systems may thus increase the robustness of the industry although potential contagion effects between the providers may weaken this advantage.

2.3.2 Vertical interdependencies in the value chain

In several European countries, the dominant trading institution often also exercises control in the activities further downstream, i.e. the exchange is vertically integrated into the domestic clearing and settlement activities. This setting is mainly driven by efficiency motives as it enables to process straight-through the whole transaction in a faster, more cost efficient, and more reliable manner. Straight-through processing (STP) at a single institution offers significant economies to both users and providers in comparison to the processing between separate entities as: (1) It lowers communication costs between the respective activities thereby improving static efficiency. (2) Innovations concerning the processing of transactions are easier to implement, since coordination efforts with other providers along the value chain are not necessary. This shortens the implementation period and, therefore, increases dynamic efficiency. (3) It makes transaction failures less frequent, since the data transmission process is optimized in-house, for example by implementing a proprietary communication standard. This represents an improvement in systemic efficiency.

However, with the decline in IT-infrastructure costs in recent years, the arguments for vertical integration are not as strong as they have been some years ago as transmission costs

[23]See Giovannini Group (2001, p. 18 - 19) and de Bandt and Hartmann (2000).
[24]See Diamond (1984) on the use of such delegated monitoring as a rationale for the existence of banks.
[25]Confer de Bandt and Hartmann (2000, p. 17) for further details.

to outside institutions are now significantly less costly and not necessarily higher than in-house transmission costs.

Furthermore, as trading habits of investors gradually shift from a domestic towards a more international approach, the national 'silos', as the vertically integrated entities are also called, not only no longer represent the investor's scope of transaction activities but even hamper frictionless processing of cross-border transactions in Europe. This is due to their incompatible proprietary communication standards which each national silo had developed to communicate along its own controlled value chain - a legacy that makes communication between silos a highly complex and inefficient task.

Differing communication standards between vertical silos also de facto impede the contestability of the downstream activities, i.e. clearing and settlement markets. They represent an effective entry barrier against other providers that strive to enter the market of an established silo. They are unable to do so because once a trade is made on the established trading platform competitors are restricted to offer their services for the downstream functions due to the existing proprietary communication standard of the established provider. Therefore, clearing and settlement activities of the established provider are protected by its trading activity and are thus barely subject to contestability. This may result in dynamic inefficiencies.

2.3.3 Regulation

Efficient trading, clearing, and settlement of securities is important for the functioning of the whole economy. Companies need to get access to finance, and private households need a vehicle by which they can save their financial surplus. This assigns financial markets in general and the TCS-industry in particular a pivotal role. The well-being of other industries and many people depends on it. Adverse effects spill over into other parts of the economy implying negative externalities. Therefore, regulation of the TCS-industry is a means to avoid or to mitigate these external effects.

These spill-over effects are very material in the settlement stage of the securities transaction value chain when the payment system is involved. A failure of one party to meet its obligations might lead to contagion effects that have negative effects on the liquidity of the banking system and threatening the economy by this transmission channel. The central bank as lender of last resort has an incentive to deal with these regulatory issues. It therefore needs to be (and also is) one of the key regulating institutions, since central bank money is frequently involved in settling the cash side of securities transactions. Other regulatory bodies are concerned with different aspects: For example, the performance of each activity for all users - which are of a considerably heterogeneous degree - in a fair manner needs to be ensured, i.e. access to the infrastructure must be open and in an undiscriminating way. The European Commission with various reports - the Lamfalussy Report, the two reports of the Giovannini Group, and the Investment Services Directive - is committed to this task in the Single European Market. National agencies implement actions to put these aspects into practice today. Regulators often join their forces to set standards after consulting the relevant industry players, e.g. the joint working group set up by the European Central Bank and the Committee of European Securities Regulators (CESR). A single European Financial Services Authority might one day take over this job. In all cases, the right balance between static, dynamic, and systemic efficiency must be chosen by regulators.

Regulation lowers static efficiency, since it is costly to set up a bureaucracy - or a publicly owned entity in the extreme - to achieve the performance of the three activities in the value chain. The 'outsourcing' of regulation to the providers and to the users of the infrastructure could be a cost-efficient alternative. Possible means for this outsourcing lie in the self-regulation by the infrastructure provider. Whenever they can compete on quality, as many exchanges do with different market segments and the attached regulatory conditions, regulation need not be of the costly public variant. As a second means, the infrastructure can also be user-governed. In this setting, the club of users writes its own rules. Whenever little entry in this club is required, this can again be better than publicly provided regulation.

The current system with competing regulatory regimes in Europe - with sometimes overlapping competencies, sometimes unattended areas - is seen nearly unanimously by the industry as a major barrier to business, since a level playing field is not provided. We come back to the question of regulation in the context of the three efficient systems in Section 2.5.

2.4 Strategic conduct - The provider's action set

In this section we analyze the three key parameters in our framework that the providers of the infrastructure, the users, and the regulators can use to interact strategically to shape the future of the securities transaction industry. The focus is on the providers of the infrastructure, possible actions and reactions of the other constituencies are taken into account where necessary. The three parameters in the action set that we look at are (1) the boundary decision of the infrastructure providers, (2) the decision whether to adopt an open standard or to develop a proprietary communication tool, and (3) the governance of the infrastructure providers.

2.4.1 Boundary decision

The institutions providing the infrastructure for trading, clearing, and settling the different financial instruments face the problem whether to integrate different activities in the organizational design of one firm or whether to concentrate on just one function or one specific financial instrument. We describe two distinct business models - the vertically integrated silo and the vertically focused firm.

The vertically integrated silo The first business model is the vertical silo - the combination of trading, clearing, and settlement under the roof of one firm. It is applied, for example, by Deutsche Börse. The advantage of such a model is that it allows to reap the benefits that derive from the economies of scope between the three functions as described in Section 2.3.2. Communication is easier when the three functions are performed in close proximity within the same organization. Specific forms of data exchanges between the three stages of the value chain and straight-through processing allow for the emergence of economic rents.[26]

However, one of the adverse effects such a business model has, which might be a prevalent microeconomic motive behind this strategy, is the leverage of a (natural) monopoly on one stage of the value chain upstream or downstream to other stages. Particularly, a vertical silo may cross-subsidize its trading costs - and thereby attracting customers from other platforms - through its monopoly profits on the clearing and settlement stage or vice versa.[27] By this strategy, an institution following the business model of vertical integration effectively strengthens its competitive position. Furthermore, the vertical silo forecloses the market for competitors: By restricting access for them in one activity, users can be forced also to 'buy' the solution for

[26]See Williamson (1985) for the role of specificity in explaining vertical integration.

[27]The detrimental effect of vertical integration on horizontal consolidation between different infrastructure providers on the same stage of the securities transaction value chain is formalized by Köppl and Monnet (2003) in a mechanism design model taking into account the asymmetry of information between the different players.

another activity from the same institution. If there is no choice for them but to deal with the same provider, a monopoly rent can be extracted from the users, thereby further increasing the economic rents generated in this model due to the specificity inherent in it.

Therefore, the interesting question arises whether Deutsche Börse can deliver its promises given that it controls downstream activities and de facto can foreclose the market due to its monopoly on the following stage in the value chain. When faced with the specific and co-specialized investments they have to undertake, banks and brokers could be reluctant to join in this venture.

The vertically focused firm The other business model that has promising features is that of more focused infrastructure providers and the use of market mechanisms between different stages of the value chain. A prominent example for this industry setting was used in England where three independent institutions, namely London Stock Exchange, London Clearing House, and Crest, provided infrastructure services only for one stage of the value chain, respectively.[28] If a good solution for the data transfer between the three activities of the securities transaction value chain is implemented, this model has appeal because it does not give too much power into the hands of a single entity that can control access to its infrastructure - an infrastructure that exhibits strong network effects. For each activity, the users can choose the best institution that provides it in the most efficient way. Competition forces less efficient institutions out of business and sets high-powered incentives for the surviving. As such firms do not have to worry about any interdependencies between their different lines of business, they are more eager to adopt new and better technologies and processes. Any cannibalization of value propositions within the same firm cannot happen. These institutions increase, therefore, static and dynamic efficiency. A possible drawback which might be taken into account by the regulators is less systemic stability that too high-powered incentives might induce. How the problem of establishing a market mechanism for the intermediate goods - the information transfer from one stage to the next in the value chain - can be dealt with is the topic of the next section.

2.4.2 Communication standards and accessibility

The interaction between the stages of the value chain is of crucial importance to the way business is performed in the TCS-industry. It necessitates the infrastructure providers to make decisions both on the information transfer mode, i.e. the type of communication standard, and the degree of accessibility of their activities to competitors.

Proprietary versus open communication standards Proprietary standards infer that the information format of the transactions cannot be interpreted without co-specialized investments so that competitors are discriminated against, whereas an open standard enables competitors to process the information and allows users to switch the providers more easily.[29]

The decision whether to adopt an open standard or to set up a proprietary system is intertwined with the vertical boundary decision. In the case of a vertically focused infrastructure provider the solution is trivial. Such an institution has to rely on the market for the performance of upstream and downstream activities, the communication protocol has to be in an

[28] In the past years, the London Clearing House has teamed up with Euronext's Clearnet, while Crest has merged with Belgium-based Euroclear .

[29] The battle for an unique communication standard and the different competing approaches are described in Weitzel, Martin, and König (2003).

open and understandable format.[30] The case is different for companies following the business model of a vertical silo: Such companies can develop a solution that allows them to keep the information, which has to be passed along the securities transaction value chain , private. By doing so, it can develop an idiosyncratic data exchange format that allows them to generate an economic rent due to the specific nature.

However, an economic rent could also be generated by foreclosing the market for an upstream or downstream activity. Users are forced to rely on the same institution and buy the bundled product in a one-stop shop. They have to invest in co-specialized computer systems that allow them to handle this proprietary data format. With an open communication standard between the different stages of the value chain a deconstruction becomes possible. There would be a choice for customers to deal with the best and most efficient institution.

Analyzing open and proprietary communication standards on the basis of our three efficiency concepts reveals that there are two major advantages for proprietary in comparison to open communication standards: (1) They can be more specific in relation to a certain financial instrument or a certain institution than open communication standards and thus be more statically efficient. (2) A higher dynamic efficiency can be obtained, since a proprietary communication standard allows for the complete appropriation of the economic rent that is generated by innovations. Additionally, the benefits of innovations made with open standards could be enjoyed by every participant without being obliged to invest into this innovation. Thus, underinvestment problems may arise with open standards.

However, proprietary communication has also two major drawbacks when compared to open standards: (1) Proprietary standards provide more incentives for strategic behavior to infrastructure providers which can be to the detriment of the users. Thus, market foreclosure strategies and mutual reinforcements of monopolies on different stages of the value chain can have a negative impact on users. Both static and dynamic efficiency may be impaired. A communication standard that is open to all market participants prevents or at least alleviates this strategic behavior: It is easier for competitors of the infrastructure provider or for the users themselves by means of internalization to work around such a foreclosure. (2) Proprietary standards raise more regulatory concerns if a regulator wants to ensure the proper functioning of the market and access for other constituencies. Therefore, static efficiency may be lowered due to the increased regulation costs. Additionally, systemic efficiency may be low if regulators do not control the proprietary standard properly.

Restricted versus open accessibility Accessibility is the flip-side of communications and refers to interactions between competitors across different stages of the value chain, i.e. between trading and clearing or between clearing and settlement. Open access describes the ability of institutions to provide their services on one stage of a transaction although other stages of the value chain are performed by competitors. This stands in contrast to transactions where access is restricted by a provider. Restriction of access is possible whenever a provider is able to leverage its dominant position on other stages of the value chain. This may, for example, occur if a dominant trading facility prevents other providers of downstream activities to receive the transaction and automatically route it to their own post-trading facility instead. Another example for dominance can be found in the opposite direction if a settlement provider has the monopoly on a certain security and refuses to accept transactions that are traded or cleared from anybody but its own upstream activity provider. Therefore, restricted accessibility can

[30] One could also imagine the case that a proprietary standard is used. In this case, the outcome would be a hybrid solution along the lines of Williamson (1985): Long-term contracts or strategic alliances are necessary to account for the hold-up problem, since specific investments have to be made.

strongly impede fair competition among providers in the TCS-industry.[31]

Accessibility as well as the communication standard decision primarily depend on the industry structure[32], the allocation of power between the different constituencies, and the governance and ownership of the providers of the infrastructure. Using (or being forced by a regulator to use) a common means of communication technology effectively opens markets. The power that is conveyed by open markets to users allows them to search for the best price and quality. This in turn eventually forces a redistribution of economic rents away from the incumbent providers who would otherwise hang on to an inefficient allocation of resources from a welfare perspective. It is to these governance aspects that we turn next.

2.4.3 Ownership structure and governance

Ownership of a good is an incentive device: If residual decision rights are aligned with the rights to residual income, decisions are made in such a way as to maximize this share. The maximization of it optimizes social welfare whenever these decisions can be made independent of others. It therefore matters who ultimately has control over a certain good or resource. This is also the case for a firm - a much more complex 'good' and a whole bundle of resources. For our analysis, we take into account the ownership structure of a provider of the infrastructure in the securities transaction value chain to check whether economically sound decisions will be made by this institution. Three distinct forms of ownership can be identified: (1) A for-profit firm that operates to maximize the profit that is distributable to its shareholders as dividends, (2) a nonprofit mutual that operates to maximize the utility of its members, and (3) a publicly-owned entity that provides a good or service that would not be provided efficiently by a private firm due to its public good nature and the underlying external effects.

Public ownership of an infrastructure provider can be a means to deliver a service that must be provided by a natural monopolist. The public policymaker, acting in the interest of society as a whole, is not interested in narrow profit motives but rather tries to provide this service in the efficient quantity. This gain is, however, very likely to be offset by inefficiencies that public bodies bring with them. Without a profit motive the resulting incentives in the publicly owned firm are weakened and inefficiencies are reintroduced.

In recent years, many publicly-owned monopolies in diverse industries were privatized, and for-profit firms were established instead. In this form of ownership - the standard capitalist form most commonly analyzed in economic theory - the residual decision rights are aligned with the residual claims and better incentives are thereby conveyed. The public interest of the provision of the right quantity for the correct price in these network industries is better served by a regulator who has less decision power (and less potential for meddling) than an outright publicly owned enterprise. The shift in control and power away from a public authority towards the private agents that use and provide the infrastructure increases overall welfare by nurturing better decisions because the resulting economic rents are exploitable by these decision makers.

The third possible ownership arrangement is that of mutual ownership. In the mutual form, the users of the infrastructure provide the necessary investments themselves, so that the statically efficient quantity is produced for a price that is lower than the monopoly price. The direct users are members in the providing institution and take into account the supplementing

[31]See also Milne (2002) who proposes to regulate access to the book transfer (which would fall under the notion of settlement in our argument) as he identifies it as the natural monopoly within the clearing and settlement industry.

[32]There is a strong interdependency and complementarity between accessibility, communication standard, and vertical boundary decision of the providers: We observe the tendency that a vertically integrated firm often employs a proprietary standard with restricted access, while a vertically focused firm prefers open standards and open accessibility.

function that the infrastructure has for their core business in which they ultimately want to generate economic rents. The amount of economic rent that is generated in such a mutually-owned institution is therefore lower compared to a for-profit firm, while inefficiencies are reduced in comparison to a publicly-owned and over-regulated authority. Such a structure has its drawbacks, however. The membership of the mutual can procrastinate, and new entrants can be discouraged from using the same infrastructure. If the members are too heterogeneous, the governance of 'one member - one vote' instead of 'one share - one vote' can cause decisions to be distorted by the divergent interests, and the larger players can be held up by the smaller constituencies.[33] In recent years there has been a wave of demutualizations, especially among exchanges, due to these problems.[34]

Why are ownership and governance aspects important? The governance of the infrastructure providers is of particular importance for the efficiency with which securities transactions are performed. The Council of Institutional Investors, representing 130 pension funds holding $3 trillion in assets in the USA, criticizes that of the three constituencies of the New York Stock Exchange - members (intermediaries like broker-dealers and specialists), listed companies, and investors - only the members are allowed to vote and to choose the board. This structure has a potential negative effect on the self-regulation of the exchange, since that is biased towards the members' interests.[35]

The governance structure also influences the ability of a firm to innovate and to be efficient in a more dynamic sense. Too much power in the wrong hands hinders the necessary innovation in the face of disruptive technologies. The introduction of electronic trading systems, for example, was heavily fought by floor-based brokers that have an important voice in the governance of exchanges. If these are not only the users of the infrastructure but can also exert power through a mutual ownership arrangement, they can block such innovations that would make them worse off but lead to large gains for other users.

2.4.4 Interdependencies in the action set

The three described action parameters are not independent of each other. We want to highlight some interdependencies here as a precursor to the comparative analysis of the three organizational designs in Section 2.6.

Boundary decision and communication standards Open standards are a means to credibly commit an institution performing a certain function in the securities transaction value chain not to pursue a foreclosure strategy through vertical integration. The leveraging of a natural monopoly on one stage of the value chain for a certain financial instrument cannot be used to force customers to use the infrastructure of the same institution on the previous or next stage in the value chain as well. The choice for customers and the threat of market entry by upstarts do not allow institutions to use their power to extract more than their 'fair' share of economic rents generated by the activities of the securities transaction value chain. This makes a strategy of vertical integration less attractive. On the contrary, in such a setting it would be necessary for the integrated institution to compete with many focused firms that know their activity by heart. Any advantage in terms of higher economic rents these focused institutions can gain can only come from better service, which leads them to pursue a strategy that puts

[33] Hart and Moore (1996) present a model in which the heterogeneity of users makes a mutual structure less preferable.

[34] See also Domowitz and Steil (1999, p. 14 - 16) on this issue.

[35] See the Economist (2003, p. 59) for this example.

a premium on innovation. Even if the vertically integrated firm also pursued aggressive R&D activities, it would be faced with the dilemma of cannibalizing its own success whenever it came across an innovation on one stage of the securities transaction value chain that would force it to restructure the relationship between the integrated stages. The need to meddle with transfer prices weakens incentives for middle managers or even leads to outright sabotage of the new product or process by the managers of the less innovative stage.

Ownership structure and communication standard Economic rents can be generated by for-profit firms by suitably using the ideas of industrial organization theory to structure the industry to make it more difficult to enter the market. One such tool is a proprietary standard probably in combination with a strategy of vertical integration. In the other two ownership forms we described - public and mutual ownership - these incentives to foreclose the market by opting for a proprietary communication standard are not that prominent, since the appropriation possibilities of any rents generated are less good for the owners of such institutions. In the case of a publicly provided infrastructure of the natural monopoly functions this institution will settle on its own (proprietary) standard, but fair access is usually granted by the provider of the public good. In the case of a mutual ownership structure the tendency is for an open communication standard, because the users themselves will gain from less diversity between different providers: In this case they have to invest only in one system to cope with data from numerous institutions on the other stages of the securities transaction value chain. However, incentives to develop the common standard and to take account of better possibilities in data exchange through broadband connections and better encryption and decompression algorithms are needed. One possibility is the use of open source-like structures: Franck and Jungwirth (2002) see the advantage of such structures in donations that are made by interested constituencies without a crowding out of valuable investments in the case of an emerging standard. Cooperatives are then a preferable organizational form that allows to establish a standard without the effects of competition that would lead to a fragmentation or to a lock-in into an inefficient system.[36]

Boundary decision and ownership structure Mutually owned organizations have their drawbacks in terms of slow decision making and weakened incentives due to the lack of the profit motive. Vertical integration augments this disadvantage by making the organization even more complex. The users of the infrastructure for the securities transaction value chain are therefore more likely to set up several cooperatives, each one highly focused along the value chain that have probably different members and to rely on open standards for the exchange of information between them. The users themselves restrict the activities of a cooperative to the absolute necessary.

The solution of public ownership is more likely to be vertically integrated, but a sensible and economically minded policy maker would again opt for a deconstruction of the value chain and a private provision for the activities where this is the best option. Unregulated private organizations that run in the best interest of their shareholders are very likely to pursue a strategy to shape the industry in their favor and to erect entry barriers whenever possible. As mentioned before, a foreclosure strategy of leveraging a monopoly position from one activity to the next makes perfect sense for such institutions. Privately-owned companies are therefore likely to increase their scale and scope by actively integrating along the value chain when no countervailing forces prevail.

[36]For a theoretical underpinning of cooperatives and their investment incentives in emerging standards see the work of Rey and Tirole (2001).

We have now outlined the constituents of our framework and discussed them in detail. In the following section we put these parameters together to concentrate on the systemic relationships between them that make some configurations more efficient from a perspective of maximizing overall welfare than others.

2.5 Proposals for an efficient organizational design

Systems in general consist of various modules. Between these modules or elements there can be a complementary relationship. Complementarity between any two such elements implies that the simultaneous increase in both elements leads to an overall superior performance. In the case that such a complementary relation between the elements of a system exists, the right configuration of these modules matters. Only if they are adjusted for supermodularity, the design in question will be internally consistent. Such a consistent system will perform better than any system in which deviations from the coherent configuration in one or a few parameters occur.[37]

This section presents three idealized systems where the configurations of selected elements, especially the parameters of the action set described above, are set thus that the complementary relationship is taken into account and the overall system is efficient from the viewpoint of a benevolent system designer. Small deviations from the configurations suggested lead to an overall less efficient solution.

2.5.1 System 1 - Regulated monopoly

Description The system of a regulated monopoly has two distinct features implied by its name: (1) There is no competition in the provision of the activities on those levels of the securities transaction value chain that are consolidated and (2) the role of the regulator is very pronounced in these stages. Usually the roles of regulators and providers are combined, and the infrastructure is publicly owned.

The horizontally consolidated and possibly even vertically integrated structure can take several forms depending on the scale of integration in each activity. In the USA, for example, the Depositories Trust & Clearing Corporation is the monopoly for clearing and settlement activities, and trading occurs on several exchanges. Many national markets in Europe were structured as a vertical silo with all three activities integrated into one entity. What are the advantages of such a system?

The consolidation in each activity allows to reap economies of scale and scope along the securities transaction value chain for the providers. Users, on the other hand, enjoy the strong benefits of a single network. The public ownership and the lack of competition lead to low incentives to innovation activity. The threat of entry is subdued, since the underlying economies as well as the publicly sanctioned role as the sole provider entrench this institution.

Vertical integration even enhances this entrenchment, but also leads to the possibility of straight-through processing and an efficient use and dissemination of information from one stage of the value chain to the next. The low rate of innovation and the resulting stability in the industry makes it feasible to write detailed plans. The low innovation activity is also consistent with a low investment propensity of all players and low total investments. The

[37]Recall that mathematically, complementarity relates to a positive cross-derivative: The first-order returns for the increase in one element are still more enhanced if the second element is also increased. Consistency is the characteristic that any pairwise combination between any two elements has a nonnegative cross-derivative - also referred to as a supermodular relationship - between them. Confer Topkis (1998) for a mathematical approach.

users of the infrastructure are willing to undertake the necessary co-specialized investments. The standardization process is organized by the regulator, which uses its powerful position to enforce and set the standard means of communication. The sum of total investments is low, since no company can compete with such a vertically integrated, publicly owned organization that uses the underlying economies of scale and scope.

Figure 2.1 provides an illustration of possible industry outcomes of a regulated monopoly as well as the position of the power center between the constituencies.

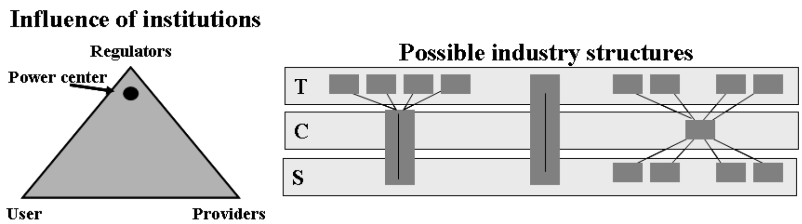

Figure 2.1: TCS-System 1: Regulated Consolidation

Efficiency analysis Static efficiency in these settings is relatively high due to the strong exploitation of network, scale, and scope economies. The significant market power of the providers has its counterweight in the public ownership structure, so that the inefficiencies of a monopoly do not prevail. However, the incentive structure within a big public agency brings also some costs in terms of lost efficiency. It depends on the actual processes and organizational structures of this body whether the combined effect is still positive.

Dynamic efficiency is rather low due to the lack of competition. The pressure for product or service innovations will remain limited to the detriment of the users. The overall investment activity is too low, and potential competitors are deterred from entering the industry.

The analysis of systemic efficiency in these settings has a two-sided result. Consolidation enables the centralization of risk management at the infrastructure providers - which can be more efficient than a decentralized risk management solution. However, as mentioned above, moral hazard aspects such as the reduction of risk management efforts due to a too-big-to-fail feeling may endanger systemic efficiency in these settings.

The regulators are the center of power in the system of a regulated monopoly. Ideally, this should reduce potential moral hazard issues in risk management and ensure fair transaction prices for the users, i.e. the users should benefit from exploited scale economies. However, regulation itself is costly, so that increasing systemic efficiency will lead to a loss in static and dynamic efficiency. This organizational design is most notably interesting when static efficiency aspects outweigh dynamic considerations. This may be the case when disruptive innovations are expected to be rather rare in the future and the processes in the industry are settled and stable.

2.5.2 System 2 - Competitive fragmentation

Description In contrast to system 1 the market structure of system 2 is rather scattered, i.e. it features polypolistic characteristics including several providers for trading, clearing, and settlement. A high level of competition on all stages of the securities transaction value chain leads to a high rate of technological innovation. The fragmented industry structure necessitates the use of open standards, since otherwise the users would have to undertake co-specialized investments to several providers. Open standards and good access possibilities allow new competitors to enter the market easily whenever they see fit. This is consistent with the high rate of innovation that is increased by such new entrants. The tendency to invest is high, since it can be the basis for Schumpeterian rents. The resulting overall investment level is, therefore, possibly too high when too many uncoordinated investments are undertaken. Overinvestment and a resulting bubble can lead to cycles of investments that exacerbate the economic cycle and the ups and downs of financial markets.

The ownership of these firms rests in private hands, since that is the most efficient incentive tool to sustain the needed rate of technological progress to keep this system stable. The role of the regulators is very subdued: Any exaggerated activity by them would lead to a lowering of investment incentives for the private companies that then would have to fear a meddling of the regulators. The only activity they should engage in is to ensure open access. Self-regulation by the competing providers is a means for them to differentiate themselves from competitors and attract more users and a better competitive advantage. The epicenter of power lies with the privately-owned providers or with the users depending on the providers' ownership structure. The tendency for vertically integrating the securities transaction value chain is low: Cross-subsidies from one stage to the next are not possible due to the fierce competition on each stage, and the reluctance for change in such a vertically integrated institution that is faced with cannibalizing its own success whenever new processes or products occur, makes it a suboptimal solution.

Figure 2.2 provides an illustration of the industry setting as well as the position of the power center.

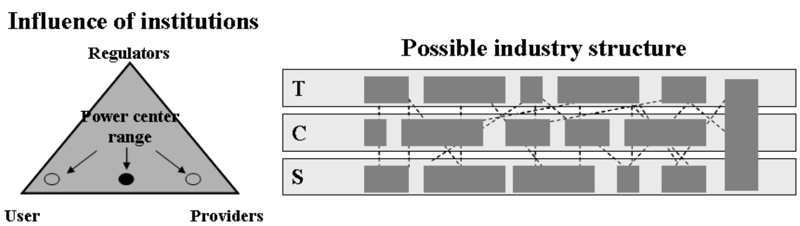

Figure 2.2: TCS-System 2: Competitive Fragmentation

Efficiency analysis Static efficiency is low in this setting. The relatively small size of the providers does not allow for the harvest of scale and scope economies. Also, positive network effects for the users remain unexploited due to the large number of smaller networks in this fragmented industry setup. Consolidation efforts exist, but a constant stream of new industry entrants armed with new, innovative products and services prevent the creation of one dominant monopoly. A system with several relatively small market participants prevails.

Dynamic efficiency, on the other hand, is high due to fierce competition and low entry barriers of the market. Open communication standards ensure that providers with better services will be able to offer their service to users without being strongly hampered by established providers. Users such as banks can effectively threaten providers to internalize transactions, should they not be satisfied with existing products and services. An exact configuration of the elements is necessary to keep this system stable between two countervailing forces. On the one hand, an industry setting with open standards may not provide enough incentives for the providers to develop the standardized technology further due to free-riding inducements. On the other hand, uncoordinated investments can lead to value destruction when too much is invested in boom times of a cycle. The system has therefore to strike a delicate balance between this under- and overinvestment problem.

Systemic efficiency is rather high. Although this setting has no (public) regulator but is mainly self-regulated, the robustness in the provision of securities transaction possibilities is, nevertheless, quite high. The driving factor is the competition among providers, in this case, the competition for the most stable and secure transaction system. Thus, infrastructure providers have an incentive to compete on quality and create a safe TCS-environment for their clients. However, an important precondition for this scenario is the transparency of the providers' risk management efforts to the users. If it is difficult for the latter to evaluate the quality of risk management, the providers may have the adverse incentive to boost profitability by cutting down on costly risk management procedures and endanger systemic efficiency. This race-to-the-bottom effect may be prevented by a user-dominated governance structure.

Another positive aspect of the competitive fragmentation on systemic efficiency is that the fragmented market structure which is characterized by high levels of infrastructure redundancies and open standards enables a relatively easy re-routing of transactions in emergency cases. Ample substitution possibilities for the users and low switching costs due to open communication standards ensure systemic robustness in times of the failure of one institution. However, depending on the nature of an adverse systemic event, contagion between the different transaction systems may occur and thus neutralize the positive redundancy aspects.

A system of competitive fragmentation is particularly interesting in a dynamically changing environment when returns on innovations are high and static efficiency considerations are dominated by dynamic efficiency aspects.

2.5.3 System 3 - Contestable monopolies

Description There are two crucial characteristics to the third system we propose: (1) The market for infrastructure providers is more or less consolidated and (2) communication between the industry participants - both horizontally and vertically - is performed via open standards. New entrants into the market are able to communicate with the others and are granted access to established providers. The efficient size with respect to scale and scope economies limits the number of direct competitors on each horizontal stage, and natural monopolies prevail. The users benefit from the merits of a large single network. Vertical integration is rather detrimental in such a system, since the monopoly positions on different stages could be used strategically by the providers to reinforce rent extraction possibilities in other activities to the disadvantage of the users. Two possibilities exist by which such behavior can be ruled out: For one, a public regulator can ensure open access and limit any vertical integration attempts. For the other, the users themselves can mutually own the necessary infrastructure and restrict such behavior by the management of the provider in question. Depending on which concept is used to restrict the infrastructure provider from capturing too large a share of the economic rents, the epicenter of power is somewhere between the regulators and the users.

Open standards and guaranteed access allow new entrants to enter the market and further limit the rent appropriation potential of the incumbent. With better products or processes they are in a good position to challenge the incumbent and to gain the upper hand eventually. The rate of technological progress and innovation is therefore higher than in system 1 of a regulated monopoly. The investment propensity and also total investment are higher, since the incumbent has to keep up with the innovative progress or risks to become obsolete and to lose his position to an upstart. Again, self-regulation can be a means of competition with the better quality and stability gaining an advantage. This allows to reduce the public regulation and the costs associated with it.

Figure 2.3 shows idealized industry structures in analogy to system 1. The boxes with dashed lines illustrate potential new entrants into the industry.

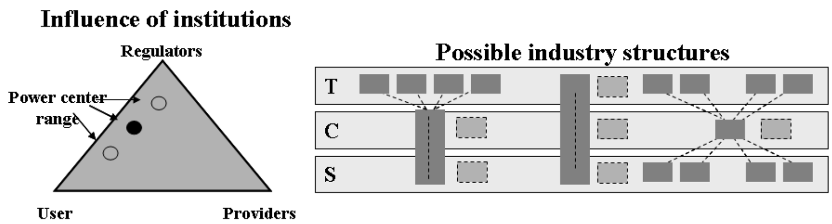

Figure 2.3: TCS-System 3: Contestable Monopolies

Efficiency analysis Static efficiency in a system of contestable monopolies is enhanced in this setting due to the high level of consolidation in the three stages of the value chain. The existence of a quasi-monopolistic infrastructure enables full exploitation of existing economies of scale and scope and network effects. Static efficiency gains are passed on to the users in this system, as each level on the value chain is contestable to market entries due to open communication standards. Furthermore, the costs of regulation can be kept to a minimum and is not distorting investment incentives for the providers.

Dynamic efficiency is also high and is achieved by the open standards architecture which results in contestability in each activity and low barriers to entry. This prevents the existing monopolist from appropriating a too large portion of the monopoly rent as potential entrants with better service offerings pose an effective threat. Nevertheless, some barriers to entry, such as liquidity, still exist in a certain security on the trading level and allow a monopolist to reap rents from his dominant market position. These rents further ensure that the incumbent has a strong incentive to maintain this position and to react to the incentives provided thereby. As mentioned in section 2.4.2, there are also some drawbacks to open communication standards with regard to dynamic efficiency aspects such as potential free-riding behavior in the development of innovations.

Systemic efficiency is high in this system. The setting benefits from its two main characteristics of being rather consolidated and having open communication standards. The former aspect enables the industry to centralize its risk management at one institution, while the latter ensures competition for the most stable transaction system, so that the quasi-monopolist is forced to maintain a high quality of risk management in order not to lose users to other providers. Additionally, open communication standards enable a wider proliferation of knowledge on the transmission of transaction data. As communication technology becomes common knowledge, it is likely that market participants react faster and better to systemic emergency events. However, contestability of the market may also bring along adverse aspects such as the aforementioned race-to-the-bottom incentives for the provider. An effective no-bail-out commitment by governments or central banks may prevent the monopolist from assuming himself to be too-big-to-fail.

2.6 Comparative organizational analysis

The three systems described above are all consistent systems that maximize social welfare in the sense that an incremental deviation from the configuration of its elements would not lead to further improvements. As such they are better than the current, inefficient industry structure employed in the European securities transaction industry which both fails to capture the static efficiency benefits from a full-blown consolidation and the dynamic efficiency gains from competitive fragmentation. In this section we compare the three systems derived from our framework and evaluate their relative merits and drawbacks to come to a conclusion which system policy makers in the EU should strive to implement. In particular we pose the following questions:

- How robust are these three systems when small deviations from the optimal configuration occur, and how likely is a system to deteriorate into an inconsistent system that is inefficient given the micro-motives of the different constituencies?
- Which one of these three systems dominates the other two systems if social welfare is to be maximized, i.e. which system is the global optimum?

Stability of the systems and the threat of inefficient systems The first system of a regulated monopoly is very stable and not in danger of falling apart easily once its elements are configured in a consistent way. By its ownership of the infrastructure providers or by the power it devolved to its regulators, the government commits credibly to stay in this system. New entrants cannot upset this system, and the incumbent monopolist has only weak incentives to engage in innovative activities. The stability itself puts a positive feedback into the system, since long-range planning and routinization become possible that lower the cost imposed by regulation.

The system is little prone to deteriorate into an inefficient system: In many European countries dominant regulated monopolies along the securities transaction value chain ensured that the underlying economies of scale and scope could be reaped at the domestic level without incurring a too big social welfare loss due to efficient regulation. By striking the right balance between these costs, securities trading, clearing, and settlement in national markets is highly efficient, at least from a static and systemic point of view. The past has shown that such a system needs a very big shock - like the integration of formerly separate financial markets into the single European one - to overcome its inertia.

The second system of competitive fragmentation is not very stable and small deviations from the consistent configuration can lead to a deterioration into an inefficient setting. If, for example, too many uncoordinated investments are undertaken, the problem of overinvesting arises. If a bubble builds and subsequently bursts due to any sufficient macroeconomic shock, it can force these investors to sell many assets below their value. Many providers become insolvent and are forced to leave the industry. A consolidation process is started by the institutions that are in a better position.

These firms start to consolidate horizontally to achieve greater economies of scale and increase the degree of static efficiency. They also integrate vertically to safeguard this horizontal expansion and to leverage the resulting market power. Since all institutions concentrate on getting financially sound again, the rate of technological innovation drops, new entry looks less attractive, and the whole system can transire to one of the other systems or falls into inefficiency if no regulation is introduced to keep the market contestable or if the ownership is reorganized to a more mutual structure (which is the less likely possibility). The surviving institutions can extract too much of the economic rent, and their monopoly power is not compensated by a regulator.

The third system of contestable monopolies is equally hard to sustain. A monopolist on one stage of the securities transaction value chain might be tempted to integrate forwards or backwards. Such a merger of two dominant monopolies might look good at first sight: By integrating the two institutions, the communication between them can be streamlined, and straight-through processing might be facilitated to the benefit of the users. Open access is guaranteed by the acquiring institution and formally assured by the small regulator. However, the realization in practice might look different and many potential entrants are deterred by the more entrenched position of the merged institution. This protection induces the incumbent to divert its efforts towards rent-seeking and engage in investments in the 'open' communication standard that slightly favors its own business. If regulation is not adjusted accordingly towards a stronger regime, such an institution can lower the overall amount of economic rent that is generated, thereby decreasing social welfare. At the same time it can gain an economic rent for itself that is bigger than it would be in a consistently configured system at the expense of a relatively larger loss in the economic rents that the users can enjoy.

Like the system of competitive fragmentation, the system of contestable monopolies is prone to deteriorate when even small deviations from the consistent configuration occur. The micro-motives of the infrastructure providers will generally lead to a situation in which a monopoly prevails that is entrenched through vertical integration, a proprietary communication standard, and an ownership structure that places too little weight on the benefit of the users and society as a whole. Such a mixture of different configurations will not maximize overall welfare.

Evaluation of the systems and global optimum So far we have not discussed if one of the idealized systems is better than the others. Calculating an exact figure for social welfare in each of the three systems is nearly impossible: Too many parameters would need to be measured, and too many errors would be made in measuring the efficiency of the organizational design. We therefore restrict ourselves to indications only. Which of the three systems might be the global optimum that dominates the others? The system of a regulated monopoly produces at an efficient level, so that economies of scale and scope can be reaped. However, it fares poorly when dynamic aspects of efficiency are taken into account. No investment incentives are set, and the cost of regulation or public ownership further decreases the overall welfare generated by this system.

The system of competitive fragmentation scores especially high when aspects of dynamic efficiency are important. However, due to the small scale of the providers, too little of the underlying economies are utilized. The system suffers also from the coordination problem between the different firms, so that too many duplicate and incompatible investments are undertaken. The system of contestable monopolies does not have these drawbacks once configured in a consistent way: The small number of institutions deploys the underlying economies of scale and scope, and the limited role of the regulator ensures that these costs are kept to a minimum as well. The market stays open for new entrants, so that improvements due to innovations do not need to be forgone.

This guesstimate leads to the conclusion that the third system of contestable monopolies is the best and should be implemented in the TCS-industry in the European Union. A caveat must be applied, since this system is of rather instable nature and prone to slide down towards an inefficient system of unregulated monopoly if not adjusted in a consistent way. Table 2.1 summarizes the merits and drawbacks of the three systems.

		Regulated Monopoly	**Competitive Fragmentation**	**Contestable Monopolies**
Action set	Boundary decision	strong horizontal consolidation, vertical integration, STP-possibility, no need for transfer prices	low horizontal consolidation, VI detrimental: cross-subsidies and cannibalization effects	strong horizontal consolidation, VI detrimental: incentive to appropriate open standard
	Standard and accessibility	proprietary standard, closed system	open standard, open access	open standard, regulated access
	Ownership and governance	public ownership, not for profit, heavy public regulation	private ownership, for profit, self-regulation as parameter of competition	private ownership (possibly as mutual), for profit; 'regulation light' or self-regulation
Constituencies	Users	low level of decision making power (DMP), low investment propensity	low - medium level of DMP, (too) high investment propensity	high level of DMP if mutual ownership, else lower; low - medium investment propensity
	Providers	very few players (possibly only one), low – medium level of DMP, low investment propensity	many players, high level of DMP, (too) high investment propensity	very few players, Low – medium level of DMP, low – medium investment propensity
	Regulators	high level of DMP	very low level of DMP	medium level of DMP if providers are not mutually owned, else lower
Comparative analysis	Static efficiency	high due to realized economies, lessened by regulatory costs	Low due to unrealized economies	high due to realized economies, low regulatory costs
	Dynamic efficiency	very low due to lack of competition, low technological progress, high entry barriers	Very high due to competition, high technological progress, low entry barriers	high due to threat from potential competitors, Medium technological progress, Low – medium entry barriers
	Systemic efficiency	high due to centralized risk management, possible moral hazard problems	High due to redundancies and open standards, Lessened by low coordination among players (over-investment)	high due to centralized risk management; moral hazard issues unlikely due to entry threat by potential competitors
	System stability	rather robust against changes in parameters	robust as long as high degree of innovation is existent, bubble-prone	rather fragile; precise configuration necessary; regulation must ensure accessibility for potential competitors

Table 2.1: Comparison of the three idealized TCS-systems

The transformation of the securities transaction industry The introduction of the Single European Market was a strong catalyst that upset the system of a regulated monopoly that many European countries had in place. Many features of the established system were suddenly and simultaneously changed. By simply opening the markets and leaving everything else unchanged, the result, however, is inefficient. Too many inconsistent configurations of important elements are in place: Too many regulators increase the costs and thereby decrease social welfare. Publicly owned or heavily regulated institutions do not have the incentives to make the right decisions. And previously vertically integrated institutions can bar others from using parts of their infrastructure. Divergent objectives of the many regulators or unhealthy competition between them decreases efficiency even further.

The response by many regulators was to withdraw a bit and let the market mechanism work. The system in the securities industry in the European Union in the 1990s therefore had some characteristics of the system of competitive fragmentation: The rate of innovations like automated trading and the demutualization of exchanges increased dramatically, and many new entrants tried to do business in the industry. The total amount of new investments was high and duplication of investments occurred in the process of battling for the dominant position in a segment of the market. The users were fully aware of the costs imposed by the incompatible communication standards between the national institutions and tried to shape the industry to their liking.

Now that the investment boom is over and the rate of technological progress has receded a bit, the securities industry in the European Union is again at a crossroads. The rate of consolidation - horizontally as well as vertically - remains high, and many unsuccessful ventures are forced to close and leave the industry. New entrants who could keep up the pressure to innovate cannot be seen. The surviving providers try to entrench their monopoly position by vertical integration and proprietary communication standards.

It is an open question how and if their rent appropriation possibilities will be countered either by tougher regulation that would put the European securities industry back to a system of a regulated monopoly (although now at the European level) or whether the users of the infrastructure can ensure together with a cut-down regulator that the system of contestable monopolies can be reached, which is our policy advice. It is very crucial that a consistent configuration of key parameters is achieved to avoid a system with a quasi-unregulated monopoly which might be preferred by infrastructure providers, but certainly not by the users and society at large.

Chapter 3

Demutualization, Outsider Ownership, and Stock Exchange Performance - Empirical Evidence*

*This paper has been revised and resubmitted for the second round review process of the *Economics of Governance* in December 2006. I thank the participants of the seminars at Bocconi University, the European Financial Management Association in Madrid and the Paris International Finance Meeting for fruitful discussions. I am particularly indebted to Reinhard H. Schmidt, Ralf Elsas, Marco Weiss, Séverine Vandelanoite, and Samuel Lee for helpful comments.

3.1 Introduction

Several stock exchanges have been overhauling their corporate governance structure as a result of a more demanding competitive environment. A combination of factors has led to increased pressure on the exchanges' businesses. (1) The changing investment behavior of their (end)customers, now being less home-biased, resulted in increased competition for order flow amongst exchanges. (2) The deregulation of financial markets, particularly in Europe, by initiatives such as the Single European Market, but also by the Big Bang reforms in UK, opened the path for increased competitive pressure on the incumbent institutions. (3) Yet, the greatest impact on stock exchange competition can be attributed to the developments in information technology and the reduction in communication costs, which resulted in the emergence of new ways to trade securities. Remote membership, electronic order book trading, electronic communication networks, and the internalization of order flow by intermediaries became all viable threats to the traditional floor trading.

The Stockholmsbörsen was the first stock exchange to react on this changing environment by restructuring its corporate governance in the early 1990s. As most other exchanges, it was organized as a mutual, which usually comprises a one-member, one-vote control structure and a not-for-profit orientation.[1] In this restructuring process, which is commonly denoted as *demutualization*, it changed its institutional setting towards a profit-oriented one-share, one-vote structure, as we find it in a regular capitalist firm. Several other exchanges followed the suit. They have done so in expectation of improved competitiveness. A survey of exchanges conducted by BTA Consulting and presented by Scullion (2001) reveals the main motives of and expected benefits from demutualization. These are - among others - (1) to tap new sources of capital which is possibly needed to modernize their trading systems (2) to pursue business opportunities unconstrained by vested interest issues (3) to achieve better cost control and (4) to increase flexibility, efficiency and competitiveness.

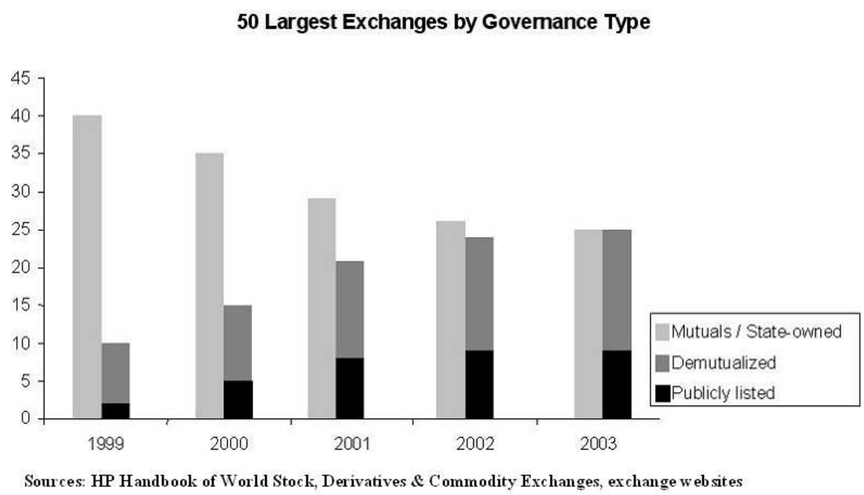

Figure 3.1: Governance Type of Exchanges 1999-2003.

Figure 3.1 demonstrates the growing prevalence of demutualized exchanges in the industry. The chart displays this development for the 50 largest stock exchanges reporting to the World Federation of Exchanges (FIBV) during the years 1999 until 2003. The number of ex-

[1] The mutual's objective function is usually to maximize its members' utility. See part III in Hansmann (1996) for an elaborate analysis on customer-owned firms.

changes that were organized as mutuals (light grey bars) fell from 40 to 25. At the same time period, the number of demutualized exchanges rose from 10 to 25. However, the demutualization process was not implemented uniformly across all exchanges that decided to change their organizational form.[2] While all of them became profit-oriented firms with equity shareholders as residual claimants, we empirically observe an important difference as to what *type* these owners are: Some demutualized exchanges retained their old shareholders and remained customer-dominated (indicated by the dark grey bars), whereas others sold a substantial portion of their shares to investors via a public listing and thereby usually became dominated by outsiders (black bars). The two groups of owners possess (stylized) differences in their objective functions: While outside investors foremost have a financial interest in the exchange, i.e. in the value of the franchise, customer-owners also take into account their business relationship with the exchange and are therefore sensitive to any potential negative externalities created on their own business due to investments undertaken by the exchange.

Some industry experts state that outsider ownership is therefore pivotal if the full expected benefits of demutualization are to be achieved. Scullion (2001), for example, argues in his contribution that

> *Demutualisation is not simply [...] turning into a for profit entity owned by members. A truly demutualised exchange would be better placed if it were able to unlock its hidden value for all stakeholders in order to maximise its potential market capitalisation and shareholder value.*[3]

A report published by the OECD takes a similarly positive stance on the effect of outside owners for demutualized exchanges. They note that

> *Being listed on a stock exchange is likely to improve the value of stock exchanges, as exchanges are urged to create value for their own shareholders through improvement of their structure to operate more efficiently.*[4]

The decision to demutualize and even to go public has far-reaching consequences for the exchanges, however. Both financial and strategic aspects need to be considered. Take for example the costs that are associated with an initial public offering (IPO). According to their annual reports, Deutsche Börse and Euronext paid 36.8 million and 46 million euros for their respective floatation in 2001. Although the proceeds received from an IPO naturally more than recouped these costs, the IPO-costs amounted to 3.7% of the new proceeds in Deutsche Börse's case and even to 12.7% for Euronext. Besides these one-off costs there are also additional running costs such as stricter disclosure requirements. A strategic implication of going public is that the creation of an acquisition currency in the form of tradable shares works in both directions, i.e. it not only facilitates the acquisition of firms, but it also opens the possibility to be taken over involuntarily.[5] We conclude that these costs must be outweighed by the benefits of restructuring the organizational form. Therefore, the positive effects of demutualization and going public on an exchange's competitiveness and hence its operative performance, should be somehow observable.

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[2] Aggarwal (2002) describes various steps of the process that exchanges may take.

[3] Confer Scullion (2001, p. xxix).

[4] Confer OECD (2003, p.104).

[5] The London Stock Exchange is the prime example for this. In 2000, it had to fend off a hostile bid by OM Gruppen, whereas in 2005/2006, Nasdaq succeeded in purchasing more than 25% in the venue without prior consent of the management of the UK-based exchange.

Related literature In academia, outsider ownership at stock exchanges has been so far predominantly analyzed from a social welfare perspective. The most prominent theoretical contribution is by Hart and Moore (1996) who discuss under which circumstances of competition and broker composition the migration from a mutual towards an outsider-owned, for-profit exchange is socially beneficial. Hart and Moore's simple pricing model demonstrates that an outsider-owned governance structure is socially preferable over a mutual structure when there exists a relatively high level of competition or a relatively high degree of heterogeneity[6] among members. An empirical contribution is made by Krishnamurti, Sequeira, and Fangjian (2003) who compare the market quality of the Bombay Stock Exchange, a mutual, with that of the National Stock Exchange, a demutualized trading venue. Another strand of literature devotes itself to regulatory issues that emerged, since some of the exchanges undergoing the demutualization process traditionally regulate their trading markets themselves. This raised concerns by industry participants whether the commercial interests of a for-profit exchange would collide with its monitoring effort to ensure fair conduct of trading. Authors such as Pirrong (2000a), Karmel (2000) and Elliott (2002), to name a few, have made important contributions in this field.

Interestingly, the impact of demutualization and outside ownership on the exchange itself, for example on its operative performance, has so far been scarcely subject to academic interest. We are aware of one paper by Mendiola and O'Hara (2003) that is directly concerned with the impact of demutualization on stock exchange performance. The paper analyzes the share price performance of publicly listed exchanges after their IPO and compares it to other listed firms and IPOs of other firms. While their results are interesting in their own right, in particular their finding that there exists a positive link between the fraction of equity sold to outside investors and stock exchange performance, it does not provide a performance comparison with exchanges that are not listed due to the apparent lack of share price information for these exchanges. Furthermore, this approach cannot provide any insights to the performance of an exchange prior to its public listing. Therefore, the use of share prices as indicator of performance is rather limited and consequently, a method that considers differences in governance regimes must be able to work with data that is available irrespective of the organizational form.

A more promising approach can be found in two contributions by Schmiedel who analyzes stock exchange performance by applying frontier efficiency methods on this industry. Both papers calculate efficiency scores for the considered exchanges without incorporating share price information. Instead, information on accounting data, staff size and transaction data is used. Each paper makes use of a different frontier analysis approach. While Schmiedel (2001) employs a parametric stochastic frontier model to evaluate the cost efficiency of European stock exchanges during 1985 and 1999, he applies a non-parametric method in the second paper (Schmiedel (2002)) for the 1993-1999 period.[7] In Schmiedel's first paper, which controls for demutualized exchanges within the regression, he find that demutualization has a positive impact on cost efficiency.[8] His second paper indicates that the mean of factor productivity gains, i.e. the annual change in technical efficiency, is higher for mutual exchanges.[9]

[6]Hart and Moore refer to heterogeneity in terms of the skewness in the members' size distribution

[7]Both methodologies are widely accepted and were already used for efficiency measurement of financial institutions by a myriad of other papers. Berger and Humphrey (1997) provide an comprehensive survey on this topic.

[8]Confer Schmiedel (2001, p.22)

[9]Confer table 7, the 'Malmquist index'-column for demutualized and cooperative exchanges on page 26.

Contribution of this paper The primary focus of Schmiedel's papers is not to elaborate on differences in exchange governance, but to apply the methodology on the stock exchange sector in general. Our paper is different insofar as it conducts an efficiency analysis that devotes particular attention to organizational forms and analyzes the causes for differences in greater detail. Additionally, our sample is more recent (1999-2003) and consequently includes a larger number of demutualized exchanges. As in Schmiedel (2002), we will also employ a non-parametric approach to calculate relative efficiency scores, albeit using a broader set of output variables in order to better capture the various activities that stock exchanges are engaged in. Furthermore, in contrast to his proceeding, we will go a step further by regressing the derived estimations of efficiency and productivity on a set of factors mapping the framework in which the respective exchanges are embedded. This procedure will then highlight whether there is a significant impact of different governance structures on the performance of the stock exchanges.

Hypotheses The purpose of this paper is therefore to determine whether demutualized stock exchanges possess a stronger operative performance than mutual exchanges. Furthermore, we want to analyze whether outsider-owned exchanges perform indeed better in this respect than demutualized, but customer-owned exchanges. As will be explained in detail in section 3.2, we approximate the operative performance of exchanges by relative technical efficiency and factor productivity scores. Our research question hence generates the following two hypotheses:

H1: Demutualized stock exchanges possess a higher technical efficiency and factor productivity than exchanges organized as mutuals.

H2: Publicly listed and thus outsider-owned stock exchanges possess a higher technical efficiency and factor productivity than demutualized, but customer-owned exchanges.

The paper is organized as follows. Section 3.2 describes the methodology used in our paper. Section 3.3 presents the employed data and our results. An interpretation as well as the robustness of our findings will also be discussed here. Section 3.4 concludes our paper by summing up our findings and drawing some policy implications.

3.2 Methodology

This section discusses the methodology used in the paper. For that matter we initially provide a brief overview of Data Envelopment Analysis and Malmquist Productivity in section 3.2.1, as these methods are employed to calculate the exchanges' efficiency and factor productivity values. Readers familiar with the methods may want to skip this section. Section 3.2.2 describes how specific effects such as different governance regimes can be disentangled via regression analysis. The structure of the employed regressions will be presented in section 3.2.3.

3.2.1 Data Envelopment Analysis and Malmquist-Productivity

3.2.1.1 Data Envelopment Analysis

DEA was introduced by Charnes, Cooper, and Rhodes (1978). Using their linear programming algorithm enables the calculation of relative technical efficiency[10] values for similar entities which process multiple inputs of resources into multiple outputs of products or services. Our focus will be on technical efficiency instead of economic efficiency as it liberates the analysis from assuming a potentially ill-defined economic objective function such as profit motivation. This is a more appropriate means to assess the relative performance between for-profit and not-for-profit entities from the same industry.[11] The efficiency scores of each entity under evaluation, which we will later denote as EFF, are determined by calculating the deviation each organization has from an efficient frontier. The frontier itself is set up as a piece-wise linear combination of best-practice observations spanning a convex production possibilities set. The computed efficiency value is thus a *relative* measure as it quantifies the performance of each entity in comparison to a set of "best"-performing peers. DEA is a non-parametric approach that has no predetermined functional relation between inputs and outputs, i.e. there are no a priori weights attached to these factors. Instead, the weighting of the factors that are involved in the production process is endogenously optimized for each decision making unit (DMU)[12] individually. By doing so, the weighting factors of the inputs and outputs, i.e. the underlying production technology, can vary substantially among the DMUs. This allows each DMU to attain the highest possible efficiency score subject to the constraint that the efficiency values of all remaining DMUs stay within the defined boundaries of the efficiency measure when using the same weighting scheme.[13] The resulting flexibility in the production function is an advantage whenever the true functional relationship between inputs and outputs is unknown. This is clearly the case in the stock exchange industry so that it seems sensible to allow for different types of production functions. Considerable uncertainty also remains on the technological characteristics of this industry. As a consequence, we will calculate efficiency and factor productivity scores for both a constant returns-to-scale (CRS) as well as a variable returns-to-scale (VRS) environment.[14]

[10] The terms technical and economic efficiency were coined by Farrell (1957). In his definition, *technical efficiency* is achieved when an increase in any output requires a reduction in at least one other output or an increase in at least one other input and if a reduction in at least one input requires an increase in at least one other input or a reduction in at least one output. *Economic efficiency*, on the other hand, incorporates information on prices for the respective inputs and outputs and an economic objective to be pursued such as cost minimization or revenue maximization. It is achieved by implementing the cost minimizing or revenue maximizing production plan. Confer Fried, Lovell, and Schmidt (1993, p. 9-18)

[11] Confer for example Pestieau and Tulkens (1993, p.300-301).

[12] The term "DMU" was introduced by Charnes, Cooper, and Rhodes (1981) and has been widely adopted by other authors.

[13] This procedure ensures that a DMU's activity can be justified from an economic point of view as it assumes that the respective decision makers act according to certain factor prices and thus give appropriate weights to the employed inputs and produced outputs in line with the notion of striving for maximum efficiency.

[14] We discuss this issue in further detail in the paragraph "Assumptions on technology".

The DEA-model Consider DMU_1 from a sample of n decision making units. Assume that this DMU uses one type of input and generates one type of output. Then, taking the output-to-input-ratio will not be very informative - save for the fact that a higher ratio generally indicates higher efficiency - unless DMU_1's ratio is compared to efficiency values of the other $n-1$ DMUs. Calculating the ratios for all n DMUs and normalizing them[15] yields *relative* efficiency values that can be interpreted in a meaningful way.

The multiplier and envelopment program The basic DEA input-oriented model[16] introduced by Charnes, Cooper, and Rhodes (1978) is based on the same simple intuition, but generalizes the ratio for the multiple input and multiple output case.[17] They calculate an efficiency ratio by assigning an efficiency-optimized *weighting* scheme to the respective outputs and inputs so that one aggregated 'virtual' output value is divided by one aggregated 'virtual' input value. To be more precise, assume that DMU_1 has an $(m \times 1)$ input vector $X_1 = \{x_{l1}\}$ with $l = 1, ..., m$ and an $(s \times 1)$ output vector $Y_1 = \{y_{r1}\}$ with $r = 1, ..., s$.[18] Further assume that there exists a weighting vector ν for the inputs and a second weighting vector μ for the outputs with corresponding dimensions. Then, the non-linear program

$$\begin{array}{llll} & \max_{\nu,\mu} & \dfrac{\mu' Y_1}{\nu' X_1} & \\ s.t. & & \dfrac{\mu' Y_i}{\nu' X_i} \leq 1 & \forall i = 1, ..., n \\ & & \mu, \nu \geq 0 & \end{array} \tag{3.1}$$

states that the efficiency of DMU_1, i.e. the output-input-ratio weighted by the transposed multipliers μ' and ν', is maximized by optimizing the weighting factors subject to the n constraints requiring that none of the DMU's efficiency value exceeds the value of one when the same weighting scheme is used.[19] However, the non-linear program has an infinite number of solutions. By adding the constraint $\nu' X_1 = 1$ to the program, the denominator of the efficiency ratio can be normalized to one so that the program's objective function becomes linear. The linearization of the constraints is accomplished by multiplying $\nu' X_i$ to constraint i $\forall i = 1, ..., n$. The resulting linear 'multiplier' program then has the following form:

$$\begin{array}{llll} & \max_{\nu,\mu} & \mu' Y_1 & \\ s.t. & & \nu' X_1 = 1 & \\ & & \mu' Y_i \leq \nu' X_i & \forall i = 1, ..., n \\ & & \mu, \nu \geq 0 & \end{array} \tag{3.2}$$

[15] This is accomplished by setting a maximum achievable value of one. Hence, perfect efficiency is achieved at a ratio of one, while a value of zero indicates absolute inefficiency.

[16] Input-oriented models calculate the DMU's efficiency in terms of the employed quantity of inputs in order to produce a given level of output. Output-oriented models on the other hand determine the efficiency by focusing on the level of produced outputs holding the level of inputs constant. Thus, the choice of the model depends on whether the emphasis is on input reduction or output augmentation. It is reasonable to use an input-oriented model when analyzing the stock exchange industry as the inputs can be influenced more directly by the management than the "outputs" which are predominantly influenced by market demand.

[17] Several refinements of DEA have emerged in the literature. An overview provides chapter 3 of Charnes, Cooper, Lewin, and Seiford (1997).

[18] The observations are all non-negative, i.e. $x_{l1}, y_{r1} \geq 0 \quad \forall l, r$.

[19] The fourth line in equation (3.1) requires the multipliers to be non-negative. Furthermore, it is assumed that the technology under consideration is convex and has the property of disposability in its strong version.

This program is solved n times, i.e. for each DMU individually. When using matrix notation and employing an $(s \times n)$ matrix of outputs denoted as $\mathbf{Y}$, and an $(m \times n)$ matrix of inputs denoted as $\mathbf{X}$ the program in (3.2) can be written as:

$$\begin{aligned} & \max_{\nu,\mu} && \mu' Y_1 && && (3.3) \\ s.t. & && \nu' X_1 &&= 1 \\ & && \mathbf{Y}'\mu &&\leq \mathbf{X}'\nu \\ & && \mu, \nu &&\geq 0 \end{aligned}$$

The program now yields a unique solution for ν^* and μ^*.[20]

The dual program The *dual* of equation (3.3), termed as the "envelopment-problem", is usually preferred to the multiplier problem due to lesser calculation effort.[21] It also provides a different point of view to the problem. In particular, the envelopment problem

$$\begin{aligned} & \min_{\theta,\lambda} && \theta && && (3.4) \\ s.t. & && \theta X_1 &&\geq \mathbf{X}\lambda \\ & && Y_1 &&\leq \mathbf{Y}\lambda \\ & && \lambda &&\geq 0 \end{aligned}$$

solves for the highest possible radial contraction, i.e. the minimum value of θ, with which the analyzed input vector (X_1) uses at least as many inputs as a linear combination of observations from the reference or best practice set ($\mathbf{X}\lambda$), while producing (Y_1) at most as many outputs as the linear combination of best performing peers ($\mathbf{Y}\lambda$).

Assumptions on technology The presented linear program has a relatively strong assumption about the underlying technology. It restricts the input-output-process to a constant returns-to-scale (CRS) environment. A slightly refined version introduced by Banker, Charnes, and Cooper (1984) weakens this assumption and calculates efficiency scores in a variable returns-to-scale (VRS) surrounding, i.e. it allows for varying returns-to-scale characteristics for different levels of input-output combinations. This is accomplished by adding a further constraint to problem (3.4), namely $\mathbf{1}\lambda = 1$, so that the reference point of the analyzed DMU is now required to be a *convex* linear combination of efficient DMUs.

3.2.1.2 The Malmquist-productivity index

The Malmquist productivity was introduced by Caves, Christensen, and Diewert (1982). While DEA measures the relative efficiency of a DMU for a certain year, the Malmquist-productivity index compares year-on-year *changes* in technical efficiency. The method gained additional appeal when Färe et al. refined it by decomposing the productivity change into two separate effects, namely the *change in efficiency* and *technological progress*. In the following, we sketch

[20] Linear programs are solved by the Simplex-Algorithm.

[21] As the number of DMUs ($= n$) is usually larger than the sum of the inputs and outputs ($m + s$) used in the program, the dual needs to calculate $n - (m + s)$ fewer constraint.

the fundamental issues of this method.[22]

Consider the left panel of figure 3.2 (CRS) where a DMU's one-input (x), one-output (y) constant returns-to-scale production process is depicted for two subsequent periods t and $t+1$ with respective efficient production frontiers T^t and T^{t+1}. Irrespective of the observed input-output-combinations (x^t, y^t) and (x^{t+1}, y^{t+1}) the slopes of the two best practice frontiers indicate whether *technological progress*, which we denote as $\Delta TECH$, has occurred from period t to $t+1$. As the slope of T^{t+1} is steeper than that of T^t, technology must have progressed, for it is possible in $t+1$ to produce the same amount of output with fewer inputs. This can be readily seen when focusing on points b and c in the figure which determine the inputs that are required to produce the same output level y^t in the respective periods. Thus, using technology T^{t+1} enables the same output to be converted by $(0b - 0c)$ fewer inputs. To see the *change in efficiency*, which we denote as ΔEFF, one needs to take a closer look at the actual input-output combinations, i.e. (x^t, y^t) and (x^{t+1}, y^{t+1}) of the decision making unit. Apparently, neither of the two is produced in an efficient manner. Note, that the points b and f represent the minimum input levels for the given output levels y^t and y^{t+1}. As the deviation from the frontier has increased in period $t+1$ compared to period t, there was a decline in efficiency for this DMU. In total, the two factors that comprise the productivity change of the DMU,i.e. $MQ = \Delta EFF \times \Delta TECH$, are running in opposite directions in our illustration. The right panel (VRS) depicts the case for variable returns-to-scale and can be analyzed analogously. Here, $T^t \subset T^{t+1}$ which again implies that technological progress must have occurred.

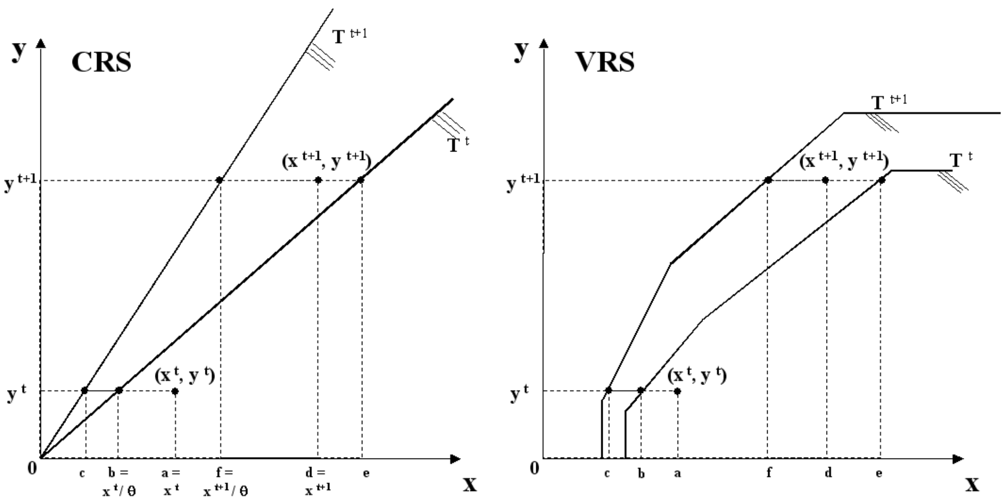

Figure 3.2: Input-oriented Malmquist approach for CRS and VRS

In order to determine the aggregate change in factor productivity, Färe et al. define input distance functions - that are the reciprocals of Farrell's technical efficiency measure - with respect to the two adjacent time periods in such a manner that they measure the maximum proportional change in inputs required to make (x^{t+1}, y^{t+1}) feasible in relation to technology T^t and make (x^t, y^t) feasible in relation to T^{t+1}.[23] They define the productivity index as the geometric mean of two mixed period distance functions[24]:

[22]Confer Färe, Grosskopf, Norris, and Zhang (1994, p.68-75) and Fried, Lovell, and Schmidt (1993, p.50-53) for a more detailed discussion.

[23]The methodology of Färe et al. for the output-oriented index is adapted here for the input-oriented approach. Confer Färe, Grosskopf, Norris, and Zhang (1994, p.69-70)

[24]The measurement of productivity in the VRS-case has to be treated with caution, since the results could be flawed as was noted by Grifell-Tatjé and Lovell (1995). Additionally, Färe, Grosskopf, Norris, and Zhang (1994,

$$MQ(x^{t+1}, y^{t+1}, x^t, y^t) = \sqrt{\frac{D^t(x^{t+1}, y^{t+1})}{D^t(x^t, y^t)} \cdot \frac{D^{t+1}(x^{t+1}, y^{t+1})}{D^{t+1}(x^t, y^t)}} \tag{3.5}$$

where the first factor uses time period t and the second factor time period $t+1$ as the respective reference technology. Equation (3.5) can be transformed into the following equation which uncovers the two decomposed effects stated earlier.

$$\begin{aligned} MQ(x^{t+1}, y^{t+1}, x^t, y^t) &= \frac{D^{t+1}(x^{t+1}, y^{t+1})}{D^t(x^t, y^t)} \cdot \sqrt{\frac{D^t(x^{t+1}, y^{t+1})}{D^{t+1}(x^{t+1}, y^{t+1})} \cdot \frac{D^t(x^t, y^t)}{D^{t+1}(x^t, y^t)}} \\ MQ &= \Delta EFF \cdot \Delta TECH \end{aligned}$$

The factor outside the square root indicates the change in efficiency as it is equivalent to the ratio of Farrell's technical efficiency for periods t and $t+1$. The factor under the square root displays the geometric mean of shifts in technology at output levels y^t and y^{t+1}, respectively. The calculation of the distance functions can again be illustrated by figure 3.2:

$$MQ(x^{t+1}, y^{t+1}, x^t, y^t) = \frac{0d/0f}{0a/0b}\sqrt{\frac{0d/0e}{0d/0f} \cdot \frac{0a/0b}{0a/0c}} \tag{3.6}$$

Note that for both factors, a value of one indicates no change whereas a value above (below) one signifies a positive (negative) change in technology and efficiency. Note further that exchanges that possess a low DEA-efficiency value will possess a larger potential to improve their factor productivity than exchanges that are already highly efficient. In the extreme, an exchange that is fully efficient in two adjacent periods cannot improve its technical efficiency at all. Therefore, we need to treat comparisons between productivity gains of highly efficient and less efficient exchanges with caution.[25]

For the m-input/s-output case, the following four DEA-like linear programs need to be solved for all $i = 1, ..., n$ DMUs in order to calculate the respective productivity scores[26], keeping in mind that the required input distance functions are the reciprocal of Farrell's input-oriented technical efficiency measure. Thus,

$$\begin{aligned} [D^t(x_1^t, y_1^t)]^{-1} &= \min_{\theta,\lambda} \quad \theta \\ s.t. \qquad \theta X_1^t &\geq \mathbf{X}^t\lambda \\ Y_1^t &\leq \mathbf{Y}^t\lambda \\ \mathbf{1}\lambda &= 1 \quad (only\ for\ VRS) \\ \lambda &\geq 0 \end{aligned} \tag{3.7}$$

gives the distance function $D_1^t(x_1^t, y_1^t)$ of DMU 1. Similarly, $D_1^{t+1}(x_1^{t+1}, y_1^{t+1})$ is calculated by substituting the indices t by $t+1$ in equation (3.7). The remaining two linear problems are mixed period calculations meaning that the reference technology is constructed from data of period t (and $t+1$, respectively), whereas the input-output-combinations to be evaluated are from period $t+1$ (and t, respectively). Hence, they provide solutions for $D_1^t(x_1^{t+1}, y_1^{t+1})$ and

p.73 FN 15) note that solutions from the mixed-period distance functions might not be feasible.

[25] In our second stage regressions we will control for this effect by employing the exchanges' efficiency values as additional independent control variable.

[26] Confer Fried, Lovell, and Schmidt (1993, p. 180-186).

$D_1^{t+1}(x_1^t, y_1^t)$:

$$
\begin{array}{lrcll}
 & [D^t(x_1^{t+1}, y_1^{t+1})]^{-1} & = & \min\limits_{\theta,\lambda} & \theta \\
s.t. & \theta X_1^{t+1} & \geq & \mathbf{X}^t\lambda & \\
 & Y_1^{t+1} & \leq & \mathbf{Y}^t\lambda & \\
 & \mathbf{1}\lambda & = & 1 & (only\ for\ VRS) \\
 & \lambda & \geq & 0 &
\end{array}
\tag{3.8}
$$

and

$$
\begin{array}{lrcll}
 & [D^{t+1}(x_1^t, y_1^t)]^{-1} & = & \min\limits_{\theta,\lambda} & \theta \\
s.t. & \theta X_1^t & \geq & \mathbf{X}^{t+1}\lambda & \\
 & Y_1^t & \leq & \mathbf{Y}^{t+1}\lambda & \\
 & \mathbf{1}\lambda & = & 1 & (only\ for\ VRS) \\
 & \lambda & \geq & 0 &
\end{array}
\tag{3.9}
$$

3.2.2 Two-stage approach for assessing efficiency differences

Section 3.2.1 presented our approach to calculate the DEA-efficiency and Malmquist productivity values. We have so far employed input and output variables which we assume are directly related to the operations of an exchange and are thus under the direct control of the responsible management. Additional factors, which cannot be controlled directly by the management, such as different organizational forms, have so far been not incorporated in our analysis. There are two different approaches in the literature that provide a linkage between the "controllable" *operational* and "non-controllable" *framework* factors.

On the one hand, there are refinements to DEA that allow for the direct inclusion of framework factors. These so-called one-stage approaches either calculate DEA-values for each group of DMUs separately and that are in turn projected on the respective efficient frontier[27] or they calculate the efficiency values for different benchmark frontiers depending in which non-controllable factor environment the respective DMUs are.[28] However, there are shortcomings to this approach. The major drawback is that DEA calculates the efficiency values for each subsample of DMUs separately. As a result, the proportion of DMUs that lie on the efficient frontier increases which in consequence dilutes the explanatory power of the method.[29]

The method used here follows a two-stage process. Stage one encompasses the calculation of efficiency and productivity values as outlined in section 3.2.1 and is based solely on operational inputs and outputs. In the second stage, the resulting values for efficiency and productivity are used as statistical estimators in a regression analysis. These estimators are regressed on framework factors, such as different governance regimes, that may also have influence on exchange efficiency and productivity. The procedure therefore enables us to disentangle the individual effects of these variables and provides a solid basis to judge whether there are significant differences in efficiency and productivity along the varying governance types.

[27]Confer Charnes, Cooper, and Rhodes (1981) who provide an example for the use of DEA with non-discretionary variables to differentiate between not-for profit and for-profit firms.
[28]See Banker and Morey (1986).
[29]Confer Steinmann (2002, p.34-35). Steinmann also provides further disadvantages of one-stage approaches.

3.2.3 Regression analysis

Using efficiency scores as dependent variable Using the DEA-scores as estimators of efficiency in a regression analysis entails the problem that they are truncated from above at a maximum value of one. Hence, instead of a regular OLS regression, which would produce biased results, we follow Dusansky and Wilson (1994) and McCarty and Yaisawarng (1993) who apply Tobit regressions in order to deal with truncated observations. Taking our panel data structure into account, we use the following general Tobit model:

$$\begin{aligned} EFF_{i,t} &= X_{i,t}\beta + \epsilon_{i,t} \quad if \quad EFF^{*}_{i,t} < 1 \\ EFF_{i,t} &= 1 \qquad\qquad\quad if \quad EFF^{*}_{i,t} \geq 1 \\ where \qquad \epsilon_{i,t} &= \alpha_i + \eta_{i,t} \end{aligned} \tag{3.10}$$

Here, $EFF_{i,t}$ is the efficiency value of exchange i in period t derived from the DEA-calculation, $EFF^{*}_{i,t}$ is the true but unobservable efficiency of exchange i in period t, $X_{i,t} = [1 \quad x']$ is an $((1 \times (K+1))$ vector of K framework variables plus one and β is a $((L+1) \times 1)$ vector of parameters. The error term is decomposed into an time-invariant individual effect of the exchange denoted as α_i and an independent effect $\eta_{i,t}$ which is assumed to be uncorrelated with $X_{i,t}$. Thus, we will employ a random effects model. The $K = 10$ framework variables used in this regression will be introduced and discussed in section 3.3.2. In total, we regress for $i = \{1, ..., n = 28\} \times t = \{1...T = 5\} = 140$ observations.

Using productivity values as dependent variable In a similar manner, we will regress the results from the productivity analysis on the same framework variables. The variables employed will then explain the impact on overall Malmquist productivity (MQ) as well as on the two decomposed effects, namely on the change in technical efficiency (ΔEFF) and on technological progress ($\Delta TECH$). Since there is no truncation in the productivity variables, we will employ standard panel regression equations. Thus, we obtain three regression models:

$$MQ_{i,t} = X_{i,t}\beta + \epsilon_{i,t} \tag{3.11}$$

$$\Delta EFF_{i,t} = X_{i,t}\beta + \epsilon_{i,t} \tag{3.12}$$

$$\Delta TECH_{i,t} = X_{i,t}\beta + \epsilon_{i,t} \tag{3.13}$$

$$where \qquad \epsilon_{i,t} = \alpha_i + \eta_{i,t} \qquad respectively$$

Here, $MQ_{i,t}$, $\Delta EFF_{i,t}$ and $\Delta TECH_{i,t}$ represent the values of Malmquist factor productivity, change in technical efficiency and technological progress of exchange i from period $t-1$ to period t, respectively. Again, $X_{i,t} = [1 \quad x']$ is a $((1 \times (K+1))$ vector of K framework variables plus one and β is an $((L+1) \times 1)$ vector of parameters. In these regressions we will use a fixed effects model, since the Hausman tests mostly reject the hypothesis that there is no systematic difference between the fixed and the random effects estimation - as we will see in section 3.3.3.2.[30] We will make use of the same $K = 10$ framework variables as in regression

[30] The Hausman specification test verifies whether the coefficients of a regression model with random effects are unbiased compared to the coefficients of a fixed effects model. The underlying assumption is that fixed effects models always produce consistent but potentially inefficient estimators, whereas a random effects model is always efficient but can be inconsistent. Confer for example Johnston and DiNardo (1997, p.403-404) for further details.

(3.10). Additionally, we will employ the calculated EFF-value of period $t-1$ of each exchange as a further independent variable in order to control for the fact that less efficient exchanges can potentially improve their productivity by a larger extent than highly efficient exchanges.[31] Since the dependent variables are calculated by comparing two adjacent periods, i.e. MQ_t consumes data from periods t and t-1, we "lose" one period and have therefore four observations per DMU. Thus, we regress for $i = \{1, ..., n = 28\} \times t = \{1...(T-1) = 4\} = 112$ observations.[32]

3.3 Data and empirical results

3.3.1 The sample

The study employs a balanced panel data set that includes 28 stock exchanges for a five year time period (1999-2003) as can be seen in table 3.1. The sample encompasses five exchanges from the Americas, fourteen from Europe/Africa and nine from the Asia/Pacific region. All relevant accounting and transaction data have been converted into US-dollars and adjusted for inflation.[33] Although the sample lacks completeness of the whole exchange population, it does comprise on average 85% of the total equity trading volume on stock exchanges reported to the World Federation of Exchanges (FIBV) by roughly 75 exchanges.[34] The sample includes 17 demutualized exchanges of which nine entities have also gone public, whereas eleven exchanges remain governed by a mutual structure or are partially state-controlled.[35] Taking the FIBV's fifty largest stock exchanges worldwide as the benchmark, our study includes all exchanges that were publicly listed until 2003. However, the portion of mutuals and demutualized exchanges lies at a mere 50%, respectively. This is due to the lack of comprehensive disclosure requirements for demutualized and mutual exchanges in some countries, which makes the gathering of information on their financial statements impossible. Hence, these two groups are underrepresented.

3.3.2 Variables

Table 3.2 provides an overview of the two different sets of variables employed in the analysis. They will be discussed in detail in sections 3.3.2.1 and 3.3.2.2. Accompanying descriptive statistics on the variables are given in Appendix A.1.

3.3.2.1 Operational variables

In the first stage, the DEA and Malmquist-index calculations will be based on variables that are directly related to the operations of an exchange and can be influenced by the management. An appropriate choice of variables that represent the "production process" of an exchange is not a clear-cut task. When considering input variables, it seems plausible to cover both capital and

[31] Confer our explanation in section 3.2.1, formula (3.6) and footnote 25.

[32] In order to employ White-corrected estimators to control for cross-sectional heteroscedasticity we use EViews 5 as statistical package. For the Tobit-regressions we will utilize Stata 8 as EViews does not provide a panel data version for censored data.

[33] The accounting data was acquired from the annual reports of the exchanges, whereas transaction and other descriptive data was obtained from the databases of the World Federation of Exchanges (FIBV), the Federation of European Stock Exchanges (FESE), the HP Handbook of World Stock, Derivatives & Commodity Exchanges 2001, 2002 and 2003, direct correspondence with the exchanges, company web sites and general internet research.

[34] Trading volume data from (alternative) electronic trading platforms and from banks that internalize customer orders are not taken into account. We acknowledge that these forms of equity trading gained considerable importance in recent years. Nevertheless, it is not possible to include these figures in a comprehensive and coherent fashion.

[35] For convenience reasons, the paper will denote the last type of governance structure merely as 'mutual'.

No.	Exchange	Region	Governance			Avg. World
			Mutual/State	Demutualized	Listed	Market Share
1	BOVESPA	Americas	√	-	-	0.2%
2	Lima	Americas	√	-	-	0.0%
3	NASDAQ	Americas	-	2001	-	25.7%
4	NYSE	Americas	√	-	-	25.1%
5	Toronto TSX	Americas	-	2000	2002	1.1%
6	Budapest	Europe/Africa	-	2002	-	0.0%
7	Copenhagen	Europe/Africa	-	1996	-	0.2%
8	Deutsche Börse	Europe/Africa	-	2000	2001	3.7%
9	Euronext†	Europe/Africa	-	2000	2001	7.7%
10	Hellenic*	Europe/Africa	-	1999	2000	0.2%
11	Istanbul	Europe/Africa	√	-	-	0.1%
12	Johannesburg JSE	Europe/Africa	√	-	-	0.2%
13	London	Europe/Africa	-	2000	2001	10.0%
14	Malta	Europe/Africa	√	-	-	0.0%
15	Oslo	Europe/Africa	-	2001	-	0.2%
16	OM Gruppen	Europe/Africa	-	1993	1998	1.0%
17	SWX Zurich	Europe/Africa	-	2002	-	1.5%
18	Vienna	Europe/Africa	-	1998	-	0.0%
19	Warsaw	Europe/Africa	√	-	-	0.0%
20	Australian	Asia/Pacific	-	1998	1998	0.7%
21	Hongkong	Asia/Pacific		2000	2000	0.7%
22	Jakarta	Asia/Pacific	√	-	-	0.0%
23	Kuala Lumpur	Asia/Pacific	√	-	-	0.1%
24	Philippine	Asia/Pacific	-	2001	-	0.0%
25	Singapore SGX†	Asia/Pacific	-	1999	2000	0.2%
26	Taiwan	Asia/Pacific	√	-	-	1.8%
27	Thailand	Asia/Pacific	√	-	-	0.1%
28	Tokyo	Asia/Pacific	-	2001	-	4.8%
	Total		11	17	9	**85.2%**

*: Athens Stock Exchange in 1999
†: Pro forma figures for 1999
Sources: HP Handbook of World Stock, Derivatives and Commodity Exchanges, exchange web sites, FIBV .

Table 3.1: Sample of exchanges used in the analysis, 1999-2003

labor aspects of the production process. Thus, labor will be approximated by the *number of staff* working for an exchange i in period t ($x^1_{i,t}$), whereas the utilization of capital for investments, such as the setup of an IT-infrastructure, a trading space, and the necessary buildings, are subsumed by the value of *tangible assets* employed at exchange i in period t ($x^2_{i,t}$).

On the output side, four different services are considered that can be 'produced' by an exchange. The variable $y^1_{i,t}$ stands for the *number of listed companies* at exchange i in period t. It will be used as a proxy for the exchange's effort to monitor the listed firms on the exchange in order to ensure fair trading and disclosure practices of company-specific information. Thus, the supervision of listed firms can be regarded as a service for trading participants to achieve market transparency. Secondly, the total *trading volume* in equities as well as in bonds will approximate the activities of exchange i on the cash market in period t ($y^2_{i,t}$).[36] As several exchanges have diversified their businesses into related activities such as derivatives trading and post-trading services as well as into the development and maintenance of exchange-related software systems, it is necessary to include them in the output set. Therefore, variable $y^3_{i,t}$ captures the total *number of derivative contracts* traded on the derivatives markets. Variable $y^4_{i,t}$ represents the *revenues from post-trading activities and software sales* at exchange i in period t.[37]

Before proceeding to the next section, a few words should be devoted to the choice of the proper DEA-model as was mentioned earlier in footnote 2. Considering the employed inputs and outputs in this paper, it makes sense to employ an input-oriented DEA-model,

[36] The employment of the number of transactions performed on an exchange would have been a more precise measure of the activity. Unfortunately, this sort of data was not available for all 28 exchanges.

[37] The use of revenue numbers for the latter variable is not the most appropriate figure to be included in the output set. The number of clearing and settlement transactions serviced and the number of software systems sold would have been better proxies. However, due to the lack of this type of data for all exchanges in our sample, we opted for this procedure.

	FIRST STAGE: Operational Variables
	Inputs
$\mathbf{x^1_{i,t}}$	Number of staff employed at exchange i in period t
$\mathbf{x^2_{i,t}}$	Tangible assets at exchange i in period t (in thousand dollars)
	Outputs
$\mathbf{y^1_{i,t}}$	Number of listed companies at exchange i in period t
$\mathbf{y^2_{i,t}}$	Total trading volume in bonds and shares at exchange i in period t (in million dollars)
$\mathbf{y^3_{i,t}}$	Total number of derivatives contracts traded at exchange i in period t
$\mathbf{y^4_{i,t}}$	Revenues from post-trading and software at exchange i in period t (in thousand dollars)
	SECOND STAGE: Framework Variables
	Governance
$\mathbf{DEMUT_{i,t}}$	Dummy variable for demutualized exchange i in period t
$\mathbf{LISTED_{i,t}}$	Dummy variable for publicly listed exchange i in period t
	Competitive Position and Attractiveness of the Capital Market
$\mathbf{LIQUIDITY_{i,t}}$	Level of liquidity at exchange i in period t. Liquidity is defined as the ratio of annual trading volume in domestic equity and market capitalization of domestic firms. (in %)
$\mathbf{\Delta TRADING_{i,t}}$	Relative y-o-y change in equity trading at exchange i from period t-1 to period t. The exchange's percentage change in trading volume is deducted by the sample median change of trading volume (in %)
$\mathbf{FOREIGN\ LISTING_{i,t}}$	World market share in new listings of foreign companies at exchange i in period t measured as the portion of new foreign listings at exchange i to the total number of new foreign listings worldwide (in %).
	Financial Flexibility
$\mathbf{\Delta LTFINANCE_{i,t}}$	Growth of equity and long term debt on exchange i's balance sheet from period t-1 to period t. (in %)
	Business Model
$\mathbf{OUTSOURCING_{i,t}}$	Dummy variable indicating whether exchange i has outsourced its IT-system in period t.
$\mathbf{HORIZONTAL_{i,t}}$	Dummy variable indicating whether exchange i operates a derivatives platform in period t.
$\mathbf{VERTICAL_{i,t}}$	Dummy variable indicating whether exchange i provides post-trading services in period t.
$\mathbf{FULL\ INTEGRATION_{i,t}}$	Dummy variable indicating whether exchange i is both vertically and horizontally integrated in period t.
	Control Variable for Productivity Regressions
$\mathbf{\Delta EFF_{i,t-1}}$	Corresponding efficiency values (CRS or VRS) of exchange i in period t-1.

Table 3.2: Variables used in the two-stage process

since the number of staff and the value of tangible assets of an exchange can be more directly altered by the management than the level of demand for their products and services. Thus, the management's effort to reduce the exchange's inputs seems to be a fairer yardstick than its exertion to augment the venue's output levels.

3.3.2.2 Framework variables

The second stage considers additional determinants arising from the framework in which an exchange is embedded and that may also have an influence on its performance. As noted by Fried, Lovell, and Schmidt (1993, p.53-54), the variables of the second stage may have an impact on the efficiency with which inputs are transformed to outputs, but they should not affect the production process itself. Thus, the authors require that the variables of the first and second stage are uncorrelated.[38] We will consider four types of factors that deserve particular attention and present corresponding variables that will function as proxies in our regressions. These are (1) the exchange's corporate governance regime, (2) the competitive environment and the attractiveness of the exchange's home capital market, (3) the exchange's financial flexibility, and (4) the exchange's business model.

Governance We distinguish between the following three different governance regimes: We define an exchange as (1) mutual, if the entity has not announced demutualization and operates on a one-member, one-vote basis or if it is controlled by the state. An exchange is considered as (2) demutualized and customer-owned, if the exchange announced demutualization, but has not sought a public listing yet. We thereby assume that customers mostly retain their shares in the exchange. And an exchange is considered to possess a (3) demutualized, outsider-dominated structure if it is publicly listed. Here, the assumption is that the IPO leads to a substantial substitution of customer owners by outsider owners.

To operationalize the distinctions, we define two dummy variables as shown in table 3.2. The variables can take the following configurations: (1) A mutual exchange, denoted as DEMUT=0 $\wedge$ LISTED=0, i.e. neither demutualized nor listed. (2) A demutualized exchange, denoted as DEMUT=1 $\wedge$ LISTED=0, i.e. demutualized but not listed. (3) A publicly listed exchange, denoted as DEMUT=1 $\wedge$ LISTED=1, i.e. both demutualized and listed.[39] Note that the LISTED-variable will only display the additional influence, i.e. on top of being demutualized, on stock exchange efficiency and productivity.

Ex ante, as stated in hypothesis H1 in section 3.1, we would expect that the coefficient of the DEMUT-variable is significantly positive, since this would indicate that the demutualized exchanges outperform mutuals in efficiency and factor productivity scores. Furthermore, we expect that the coefficient of the LISTED-variable is also positive, which would reflect the notion of further enhanced efficiency and factor productivity by becoming a publicly listed exchange, as was postulated in hypothesis H2.

Competition and attractiveness of capital market The degree of competitive pressure that an exchange is exposed to may have an influence on the operative efficiency and factor productivity of exchanges. We employ three variables that capture distinct aspects of competition in this industry.

Our first variable, denoted as LIQUIDITY, measures the *depth* of the market operated by an exchange and thereby provides a proxy for an exchange's importance and market power. A common way to calculate the existing level of liquidity on an exchange's trading platform is simply to divide the annual equity trading volume by the market capitalization of the firms listed on the exchange.

The second variable, denoted as ΔTRADING, proxies an exchange's *performance* capturing annual changes in the competitive position. To operationalize, we employ year-on-year (y-o-y) changes in equity trading volume at an exchange. In order to control for general trends on international equity markets we deduct from each exchange's performance the median change of the sample in the respective period. The rationale behind this procedure is the following:

[38]However, for some of our variables we cannot maintain this point as can be seen in appendix A.3, where table A.3 displays the correlation among the employed variables. In particular the correlation between the first stage variables x^1, x^2, y^1, and y^2 with the second stage variables FOREIGN LISTING and LIQUIDITY is highly positive. Therefore our coefficient estimates may possess some bias. Nevertheless, our findings remain robust when we drop the latter variables from our regressions as displayed in table A.4.2.

[39]Note that the configuration DEMUT=0 $\wedge$ LISTED=1 does not exist, since all listed exchanges underwent a demutualization process before.

A relative gain in trading volume, indicating that the exchange was able to capture more trading volume than the median exchange of the sample, signals a relatively strong competitive position vis-à-vis other exchanges. By contrast, a relative loss in trading volume would suggest a deterioration in the competitive position.

Our third variable, denoted as FOREIGN LISTING captures the general *attractiveness* of the exchange's home capital market by calculating an exchange's market share in new foreign firms listings as a percentage of the total new foreign listings worldwide. We believe that this describes the general attractiveness of a capital market quite well, since there are mainly two reason for such a behavior by a foreign firm: Either the firm is forced to list abroad, for its home capital market is not attractive, or it possess an additional listing on a foreign exchange to seek capital from these markets that presumably possess a large and thus attractive pool of potential investors.[40]

When we regress the technical efficiency and productivity of an exchange on these variables, it is difficult to establish an ex ante expectation concerning the theoretically correct sign of the coefficients. Both directions seem plausible. Consider for example the LIQUIDITY-variable: An exchange with a relatively deep market can be considered to be in a strong competitive position which may result in a better exploitation of its resources and thus in higher efficiency. The contrary may also hold as monopolistic inertia symptoms could cause excessive (input) spending and contribute to lower efficiency values. We would argue that both directions of the coefficient's sign of the FOREIGN LISTING-variable can be explained in a similar fashion. The ΔTRADING-variable may also display differing signs: It could have a positive sign when a loss in trading volume causes a decrease in efficiency. This will be the case when unfavorable market conditions coincide with lower absolute equity trading volumes, since this will negatively affect the level of the DEA-output variable $y_{i,t}^2$ and thus ceteris paribus a decrease of the efficiency value. Yet, the sign could also be negative when a loss in trading volume means that the exchange overcompensates this by a disproportionate reduction in the input variables and thereby achieves higher efficiency values. By the same token a DMU could spend overly much in its inputs than the increase in trading volume would allow.

Financial flexibility In reality we observe that several exchanges raised external funds in order to finance the modernization of their trading venues or to pursue other projects that were aimed to boost their competitiveness.[41] Thus, the financial flexibility of an exchange, i.e. its ability to raise new funds to finance investments may also have an effect on an exchange's efficiency and factor productivity, albeit it remains ex ante unclear whether it will be a positive or an adverse one. On the one hand, it could lead to inefficiencies due to overinvestments resulting from too abundant funds. On the other, the capability of acquiring new proceeds could be a necessary prerequisite to induce efficiency-enhancing investments. We employ a variable which seeks to capture the exchange's inflow of new proceeds in long term capital in each period. Ideally, we would measure this by using the respective cash flow statements of each exchange in order to capture the actual capital inflow. However, these figures are not available for all exchanges. Hence, we use a less accurate means and employ a variable denoted as Δ LT FINANCE, which captures the annual change in equity and long-term debt as is stated in the

[40] Support for this notion can be found in an empirical paper on cross-listings by Pagano, Randl, Röell, and Zechner (2001) who find that firms seeking cross-listing tend to choose foreign capital markets with large and liquid markets as well as where investor protection and efficiency of courts are high.

[41] Most explicitly this has occurred at exchanges that went public but one can imagine that - irrespective of the governance - fresh capital was provided for the exchanges to better cope with increased competitive pressure.

exchanges' balance sheets.[42]

Business model Some exchanges do not develop and operate their trading systems themselves but buy this service from an external provider. Thus, such an exchange rather incurs additional operating costs, which primarily materialize in the profit-loss statement and to a much lesser extent in its staff size and its tangible assets, which are the considered input factors in our analysis. Therefore, ignoring the outsourcing of IT-services would ceteris paribus result in a disadvantage for exchanges that develop their own trading system by employing staff and assets for that matter. Consequently, we need to control for this aspect. We do so by employing a dummy variable, denoted as OUTSOURCING, which equals one when the exchange under consideration outsources its trading system and zero otherwise. Since outsourcing ceteris paribus reduces the required input factors and hence increases the calculated efficiency values, we expect a positive coefficient sign at this variable.

We indicated in section 3.3.2.1 that exchanges extended their activities to other areas besides the classic operation of a cash market. Some of them integrated horizontally by providing an institutionalized derivatives trading venue, others followed a vertical silo model by integrating post-trading services into the existing operations. Yet others both integrated vertically and horizontally, which we denote in the following as 'fully integrated'. We have to control for this aspect, since it may have an effect on exchange efficiency and factor productivity due to potential economies of scope between the aforementioned activities. Consider for example the combination of a cash and a derivatives market, which could be operated by a single trading system, and therefore save (input) resources. In a similar fashion one could expect economies of scope when combining trading and post-trading services by utilizing straight-through-processing applications.[43] We will therefore employ three dummy variables, denoted as HORIZONTAL, VERTICAL, and FULL INTEGRATION, in order to capture the effects of horizontal, vertical and full integration, respectively. Our ex ante expectation concerning the impact of horizontal and/or vertical integration is that it should enhance exchange efficiency and factor productivity vis-à-vis exchanges that solely operate a cash market.

3.3.3 Results

3.3.3.1 Results from the first stage

In Appendix A.2, table A.2 presents the first-stage results of the DEA-efficiency and Malmquist-productivity analysis for both constant and variable returns-to-scale.[44] The mean efficiency values are greater in the VRS-case than in the CRS-case, since the VRS-efficient frontiers "envelop" the observations more closely. While this effect is relatively moderate for most of the observations, it boosts the efficiency values of some smaller DMUs like the exchanges of Vienna, Budapest and Malta considerably. Furthermore, the VRS-case computes four exchanges, namely Copenhagen, Deutsche Börse, Euronext and Malta, that are fully efficient in all five considered periods, whereas there are only two such cases in the CRS-environment (Copenhagen and Euronext). When focusing on productivity growth, both underlying technologies display an overall increase in mean factor productivity except for the 2001/2002-period where we calculated an overall stagnation in factor productivity. The most remarkable increase is

[42]In order to prevent distortions from currency fluctuations we use inflation-adjusted book values of the exchanges' home currencies.

[43]Confer Serifsoy and Weiss (2007) for a discussion on the European securities transaction industry from an industrial organization perspective.

[44]We are grateful to Holger Scheel whose program 'EMS' we utilized for the calculation of the efficiency and productivity scores.

accomplished by the Brazilian exchange BOVESPA, which improved its factor productivity by an annual arithmetic average of 29% to 34% for the respective settings.

3.3.3.2 Results from the second stage

Table 3.3 displays the results from the regression analysis using the first stage results as dependent variables as was outlined in section 3.2.3. The table presents the results of White-corrected regressions against DEA-efficiency (EFF), Malmquist-productivity (MQ), change in technical efficiency (ΔEFF) and progress in technology ($\Delta TECH$). The table is divided into two panels. The left panel displays the results for constant returns-to-scale. The right panel provides our estimates when assuming variable returns-to-scale. We numerated the columns (1-9) for convenience. Overall, the R^2-values of the productivity regressions are reasonable, save for the less appealing values in columns five and nine. For the two Tobit efficiency regressions we display the respective Wald-χ^2-values in columns two and six. When comparing the individual coefficients between the two panels we find that their signs, if significant, do not change. The results of the Hausman test demonstrate that a random effects model is likely to produce inconsistent estimates for our factor productivity regressions in all but one case (column nine), since the p-values display a highly significant rejection of the null-hypothesis. Thus, the use of the fixed effects model is more appropriate.

	Constant Returns-To-Scale				Variable Returns-To-Scale			
(1)	(2) EFF	(3) MQ	(4) ΔEFF	(5) ΔTECH	(6) EFF	(7) MQ	(8) ΔEFF	(9) ΔTECH
DEMUT	0.133***	0.001	-0.161***	0.187**	0.191***	-0.083***	-0.107***	0.025
Std. Err.	*0.047*	*0.049*	*0.044*	*0.081*	*0.063*	*0.030*	*0.030*	*0.025*
LISTED	0.040	-0.001	-0.083	0.060†	0.091	0.054	-0.068	0.127**
Std. Err.	*0.068*	*0.113*	*0.092*	*0.041*	*0.079*	*0.117*	*0.092*	*0.058*
LIQUIDITY	0.006	-0.032***	-0.002	-0.040	-0.034	-0.021	0.059	-0.063
Std. Err.	*0.031*	*0.011*	*0.022*	*0.034*	*0.043*	*0.054*	*0.063*	*0.087*
ΔTRADING	-0.002	0.008	-0.037	0.060	0.083*	0.040	0.003	0.059
Std. Err.	*0.038*	*0.034*	*0.034*	*0.054*	*0.047*	*0.039*	*0.073*	*0.077*
FOREIGN LISTING	1.804***	0.874†	-0.566	1.609*	2.347***	-0.271	-0.109	-0.218
Std. Err.	*0.388*	*0.61*	*0.848*	*0.900*	*0.687*	*0.868*	*0.503*	*1.007*
ΔLT FINANCE	-0.004	-0.029	0.029	-0.084***	-0.007	-0.026	0.054	$-0.095^{\dagger}$
Std. Err.	*0.033*	*0.069*	*0.071*	*0.018*	*0.041*	*0.073*	*0.048*	*0.060*
OUTSOURCING	0.045	-0.343***	-0.498***	0.187	-0.009	-0.400***	-0.450***	0.099†
Std. Err.	*0.059*	*0.051*	*0.056*	*0.078*	*0.065*	*0.132*	*0.088*	*0.070*
HORIZONTAL	-0.039	$-0.214^{\dagger}$	-0.300**	0.132	0.150**	-0.085	-0.154***	0.053
Std. Err.	*0.068*	*0.154*	*0.134*	*0.098*	*0.076*	*0.129*	*0.050*	*0.098*
VERTICAL	-0.006	-0.153**	-0.247**	0.137	0.180**	-0.128***	-0.116***	-0.010
Std. Err.	*0.086*	*0.065*	*0.120*	*0.138*	*0.085*	*0.048*	*0.044*	*0.053*
FULL INTEGRATION	-0.101	0.029	-0.127	0.147	0.164**	0.145†	-0.041	0.153*
Std. Err.	*0.085*	*0.081*	*0.093*	*0.140*	*0.085*	*0.092*	*0.044*	*0.092*
EFF		-1.096***	-1.003***	-0.096		-0.634***	-1.033***	0.329**
Std. Err.		*0.328*	*0.351*	*0.116*		*0.239*	*0.312*	*0.158*
CONST	0.592***	1.923***	2.032***	0.888***	0.654***	1.674***	1.977***	0.766***
Std. Err.	0.080	*0.189*	*0.151*	*0.047*	0.086	*0.142*	*0.211*	*0.129*
Observations	140	112	112	112	140	112	112	112
Waldχ^2/R^2(adj.)	54.83	0.334	0.417	0.082	55.28	0.285	0.372	-0.070
Hausman Test (p)	-	0.0000	0.0000	0.1097	-	0.0012	0.0000	0.6077

†, *, **, * * *, represent 15%, 10%, 5% and 1% significance levels, respectively.

Table 3.3: Results from the second-stage regression analysis

Results for hypotheses H1 and H2 The DEMUT-variable indicates that demutualized exchanges possess *efficiency* levels that are 13 to 19 percentage points higher than that of mutual exchanges depending on the technological setting (confer the DEMUT-coefficients in columns two and six). Focusing on the Malmquist-regressions in columns three and seven, we find no evidence that demutualized exchanges have a higher *productivity* than mutual exchanges in the CRS-case, whereas in the VRS-case they perform even significantly worse. The source of this underperformance is explained in both technology settings by a significantly lower value in improvements of technical efficiency (ΔEFF), as can be seen in columns four and eight. According to our estimates demutualized exchanges fare on average 10-16 percentage points worse on this dimension than mutual exchanges. The demutualized exchanges' progress in technology, the second component of productivity, is significantly higher in the CRS-case (column five) by 19 percentage points. As a result, they are able to compensate their underperformance in the first component insofar that the overall productivity converges with that of the mutuals' average performance. In the VRS-case, however, such a recoupment is not observable, since their improvements in technology is not significantly different from zero and therefore equals the mutuals' performance, as can be seen in column nine. As a consequence, the aforementioned resulting aggregate effect for factor productivity growth is on average lower vis-à-vis the mutuals' performance (column seven). Hence, our hypothesis H1 is only partly confirmed: While demutualized exchanges are more efficient than mutuals, we cannot confirm an outperformance in factor productivity growth.

The coefficient of the LISTED-variable, which indicates the additional effects of an outsider-owned governance structure on efficiency and factor productivity, remains largely insignificant, although its sign is positive in both EFF-regressions and in the MQ-regression of the VRS-case. The only noticeable significance can be observed in columns five and nine. Here, we find evidence that the observed pattern of demutualized exchanges, i.e. a higher technological progress, can be found for publicly listed exchanges as well. Since the variable measures incremental effects on top of the DEMUT-variable, we conclude that this effect is more pronounced for listed stock exchanges by 6 and 12 percentage points, depending on the technological setting. Overall, we conclude that hypothesis H2 cannot be supported, since neither efficiency nor factor productivity are significantly higher for outsider-owned exchanges.

Analysis of the results on the governance variables When we focus on the two components of factor productivity, we notice that demutualized exchanges are less apt in improving their technical efficiency (ΔEFF), whereas they demonstrate a stronger technological progress ($\Delta TECH$) than mutual exchanges. How can these results be explained? A plausible economic interpretation for the former observation is that governance restructuring coincides with changes in operations that leads to temporary (technical) inefficiencies until the new processes are settled and optimized. The stronger rise in technological progress of demutualized and listed exchanges, on the other hand, may hint towards an increased employment of electronic trading. This seems likely as an archaic trading floor can be replaced more easily in a demutualized governance structure, where members have a reduced influence on corporate decisions.[45]

In the following, we want to provide some support for these interpretations. First, we want to consider the explanation that the poor performance in ΔEFF by demutualized exchanges could be due to temporary frictions that occur during a restructuring period. One possible way to quantify this is by looking at the variation of the exchanges' most relevant input factors over time. If we assume that a stronger variation in input variables, such as in employee numbers or in the value of assets, is due to operations restructuring, i.e. buying new businesses and/or selling others, and if we further assume that these activities are strongly linked to the change in the exchange's governance regime, we would expect higher variation values for demutualized and listed exchanges than for mutual entities. To verify our presumption, we pursue the following

[45] Confer in particular Steil (2002) who analyzes the causes and consequences of a governance change on the exchange's trading technology.

steps: (1) We calculate the five year (1999-2003) mean and standard deviation for each of the 28 exchanges' staff sizes, tangible assets and total assets.[46] (2) By dividing each standard deviation by its corresponding mean, we obtain a variation coefficient and thus a percentage value of 'variability' for each input variable and each exchange. (3) We build three subsamples from our sample. The first group consists of exchanges that underwent the demutualization process in 2000 or 2001 in order to incorporate data prior and after the governance change. We identified the following nine exchanges: Toronto, Deutsche Börse, Euronext, London Stock Exchange, Hongkong, NASDAQ, Oslo, Philippine and Tokyo.[47] A second group comprises eleven exchanges that remained mutuals in the considered time period and that serve as a control group. These are: NYSE, Lima, BOVESPA, Istanbul, Johannesburg, Malta, Warsaw, Jakarta, Kuala Lumpur, Taiwan and Thailand. Finally, the third group includes exchanges that underwent the change in the governance regime prior to our considered time frame, which may give us an indication on the variability of input variables after the restructuring process is over. The group encompasses Copenhagen, OM Gruppen, Vienna and Australian Stock Exchange.[48] (4) We compare the three groups' mean variation values.

The left panel of figure 3.3 displays the mean variation coefficients of the three inputs and the three subsamples. The sample of demutualized exchanges (black bars) indeed exhibits a higher variability than the sample of mutuals (light grey bars), which therefore confirms our interpretation. Note also that the variability decreases for the third group (dark grey bars), which we denoted as 'Old-Demutualized' here. Thus, assuming that the variability indeed decreases after the demutualization process, we would expect that our first group may also experience less variability in the future and therefore stronger improvements in technical efficiency.

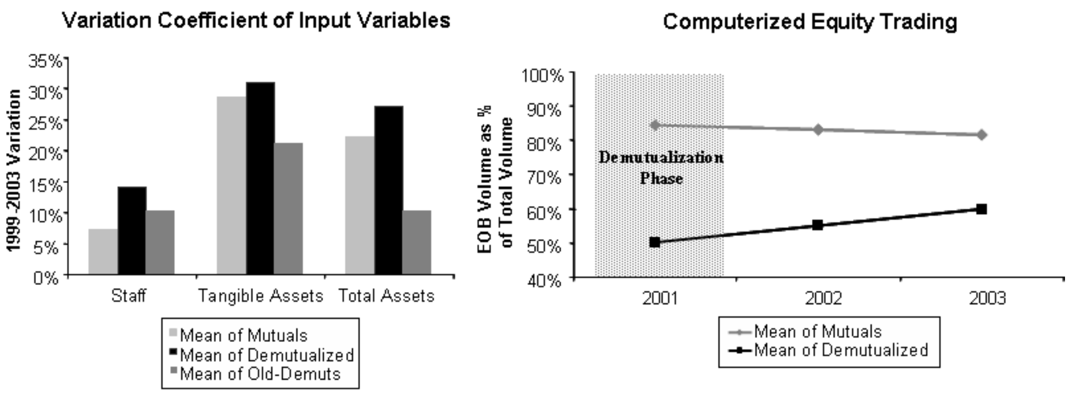

Figure 3.3: Input Variation and Computerized Trading

The second point we want to explore is whether there is evidence that the demutualization process indeed promotes technology-enhancing measures such as the increased utilization of an electronic order book (EOB). For this purpose, we calculate the portion of an exchange's annual equity trading volume that is processed by an EOB. Using the first and the second subgroup of exchanges as defined before, we can compare these groups' annual mean values. Unfortunately,

[46]In order to avoid currency-conversion effects on the values of the assets, we employ inflation-adjusted home currency book values from the respective balance sheets.

[47]Although some of these exchanges go a step further by going public it is still reasonable to subsume these exchanges under one group as the empirical results showed that both groups exhibit a similar pattern for the ΔEFF and $\Delta TECH$-variables.

[48]We did not incorporate the remaining four exchanges of our sample into the analysis, since they have either demutualized between 1999 and 2000 or after 2001. Thus, they would have distorted the comparison, for we wanted to highlight the effects of the actual restructuring process.

comprehensive information on EOB-trading is only available for the years 2001 to 2003 so that we cannot provide insights to the situation prior to the actual demutualization of the exchanges comprising the first group.

As can be seen in the right panel of figure 3.3, we identify an increased use of electronic trading by the demutualized group after their restructuring in 2000 and 2001. Yet, the increase from 50% of total equity volume to 60% within three years is dwarfed by the mean values of the mutual group. Here, we observe a slight decline from 84% EOB-use in 2001 to a still very high figure of 82%. Thus, while we can confirm that demutualized exchanges indeed seem to increasingly substitute their trading floors by EOB-systems, the findings also suggest that there is no confirmation of the argument brought forward by Steil (2002, p.62-68) that demutualization is a necessary step to overcome the brokers' resistance against an electronic order book. In the contrary, the eleven mutual exchanges under consideration used EOB-trading much more extensively than the exchanges in the subsample of demutualized exchanges.[49] The apparent prevalence of a modern trading infrastructure at mutual exchanges would also explain why they perform weaker on the $\Delta TECH$-variable: There just might have been no obvious means to improve their technology as easily as demutualized exchanges that were able to convert from a non-electronic trading technology towards an EOB.

Influence of control variables We briefly want to discuss the results from our control variables. The coefficients of the variables representing the competitive environment show that a favorable market environment tends to improve the *efficiency* of exchanges. This can be seen at variables ΔTRADING and FOREIGN LISTING in the VRS-setting (column six). They display a significantly positive relationship towards efficiency which implies that exchanges that possess an above sample-median performance in trading volume development and that have a more attractive capital market are on average also more efficient. In the CRS-environment the case is less pronounced, since the ΔTRADING variable is insignificant (column two). The impact of LIQUIDITY on efficiency remains insignificant in both technology settings. The influence of the competition variables on the exchanges' *productivity* is mixed in the CRS-case. An attractive capital market has a weakly positive effect on overall factor productivity, whereas the contrary holds for higher levels of liquidity (column three). The competition variables in the VRS-setting are insignificant.

Our variable representing the financial flexibility of an exchange, i.e. Δ LT FINANCE, displays no significant result except for a negative relation with technological progress (column five and nine). Thus, additional funds do not seem to have a positive effect on the performance of an exchange.

From our OUTSOURCING-variable we infer that outsourcing has no significant effect on stock exchange *efficiency*, while it significantly reduces overall *productivity* (columns three and seven). Focusing on the sources of this underperformance we observe that the reduction primarily stems from the negative effect on the improvement in technical efficiency (columns four and eight), while technological progress seems to increase when an exchange outsources its IT-system. For the latter point,we find weakly significant evidence in column nine.

The influence of the three integration dummy variables on stock exchange *efficiency* is negligible in the CRS-case. In the VRS-setting, all three business configurations seem to be superior to the efficiency of exchanges that merely operate a cash market. However, our robustness

[49] They might have even overdone it, as we observe a decline between 2001 and 2003. This could be explained by a return to manually executed trading for less liquid stocks. Floor brokers may handle these orders more intelligently than electronic trading systems. Handa, Schwartz, and Tiwari (2004) find evidence for this reasoning at the American Stock Exchange.

checks displayed in appendix A.4 suggest that these findings are not very reliable. Alternations to the model result in a significant change of their respective signs. Hence, we would not want to draw any conclusions with regard to the existence of economies of scope between different activities. On the other hand, our findings on *productivity* are somewhat more robust so that some inferences can be made. Here, horizontally integrated exchanges possess a lower productivity value than cash markets-only operators in the CRS-case (HORIZONTAL-variable in column three), which is mainly driven by a weaker performance in efficiency improvements (column four). A similar pattern can be observed for the VERTICAL-variable, which also seems to hold in the VRS-setting. There is evidence that fully integrated exchange have a better performance than cash markets-only venues in the VRS-case (FULL INTEGRATION-variable in column seven). However, although this outcome is pretty robust to variations in the regression model it is not significant in our bootstrap regressions. Therefore, we take a rather cautious stance regarding conclusions on the comparative performance of business models.

The control variable EFF shows that *productivity* indeed is lower for exchanges that possess higher efficiency values (columns three and seven). Thus, productivity gains are easier accomplished by exchanges with lower efficiency values.

Robustness of findings To check the robustness of our results, in particular of our findings on the two governance variables DEMUT and LISTED, we conducted several robustness checks. On the one hand, we changed the composition of our regression model in several ways to verify whether this has any significant impact on our governance variables. On the other hand, we verified the validity of our inference by using bootstrapped standard errors for our regressions.[50] In appendix A.4 we present tables A.4 and A.5 that indicate the results of the alternations to our model. Tables A.4.1 and A.4.2 display the impact on the governance variables when the variables describing the financial background and business models as well as the competitive situation of an exchange are omitted, respectively. Tables A.5.1 and A.5.2 show regressions where competition variables are substituted by other variables from the same field. Our alternations focus primarily on competition variables, since here we have the highest uncertainty about the appropriateness of the employed variables. To be more precise, in table A.5.1 we replace the ΔTRADING-variable by the same variable with a one-year lag in order to provide more reaction time for the management in case market circumstances change. Table A.5.2 displays the results when substituting the ΔTRADING-variable by a ΔLIQUIDITY-variable, which provides information on the annual change in liquidity subtracted by the median liquidity change of the whole sample. Finally, table A.6 shows our regression results when utilizing the bootstrap method.

Overall, we find that the governance variables' coefficients from our original regression model are very robust. There are very few changes in the coefficients' signs and all of those occur for coefficients that have been insignificant in the original regression or turn insignificant during the robustness check. Also the coefficients' significance is hardly affected by regression model variations and is also confirmed by our bootstrap estimates.

[50] In particular, we replicated a random drawing with replacement from our sample 2000 times in order to derive a frequency distribution of coefficient estimates that allows us to estimate a sample-specific standard error. Furthermore, we constructed 90% and 95%-confidence intervals by using the 2.5%, 5% and the 95%, 97.5% percentiles of the distribution, respectively. We also controlled for our panel data structure by using clusters. Confer Bradley and Tibshirani (1993) for an elaborate discussion on bootstrapping.

3.4 Conclusion

This paper analyzed the efficiency and productivity of the stock exchange industry for the years 1999 to 2003. The chief aim of this research was to verify, whether demutualization indeed improves the competitiveness of stock exchanges, which we approximate by calculating technical efficiency and factor productivity scores. Contrary to the statements of some researchers, our findings do not support the view that an outsider-owned exchange enhances the efficiency of the exchange. Therefore, the case for an IPO, a measure that involves considerable costs cannot be advocated from a operative performance perspective. However, a demutualization process that retains the exchange's customers as its main owners seems promising.

Another point that is commonly advanced in the literature is challenged by this paper: The assumption that a demutualization process is necessary to install modern trading systems cannot be confirmed empirically. In the contrary, the mutual exchanges of our sample have a persistently higher portion of electronic order book trading than the considered demutualized and listed exchanges. Thus, it seems that some mutual exchanges are able to adapt to new trading technologies without changing their governance structure substantially. In the spirit of the theoretical findings by Hart and Moore (1996), we would argue that these mutuals may possess a relatively homogeneous composition of member interests, thereby preventing major deadlocks on modernization decisions. However, this is purely speculative and we possess no means to empirically investigate our reasoning.

We conclude that stock exchange IPOs might have been primarily used as a solution vehicle for the diverging interests between (few) large international financial intermediaries and (many) small local brokers. The exchange's old owners possibly viewed a public listing as a catalyst to both maximizing the value of their venue and creating an exit option for those members that were unwilling to bear the costs of an operations restructuring. The fact that most of these IPOs occurred during the bull market until 2000/01, where relatively high sales prices were feasible, further strengthens this argument. Therefore, in anticipation of a substantial appreciation of the value of their voting rights, many small brokers gave up their reluctance to demutualize and their hitherto relative dominance in the control structure in favor of cashing out these rights on the stock market.

Chapter 4

Investment Behavior of Stock Exchanges and the Rationale for Demutualization - Theory and Empirical Evidence*

*This paper was accepted for presentation at the following conferences: DGF Conference in Oestrich-Winkel, Paris International Finance Meeting, Eastern Finance Association in New Orleans, WHU Campus for Finance Research Conference in Vallendar, NTU International Conference on Finance in Taiwan, and International Tor Vegata Conference in Rom, and Swiss Winter Conference on Corporate Finance and Organizations in Zermatt. We thank Reinhard H. Schmidt, Philip Bond, Hülya Eraslan, Christina Bannier, and the participants of the Corporate Finance course at the Wharton School for fruitful discussions.

4.1 Introduction

The stock exchange industry has been subject to unprecedented dynamics in recent decades, particularly in Europe and the US. Overall competitive pressure increased on many stock exchanges due to a range of significant changes of the industry environment. Besides globalization tendencies that led to less home-biased investors and issuers and consequently stronger competition between national exchanges for order-flow and listings, the deregulation of financial markets resulted in lower barriers to entry, making the incumbents' home markets more contestable. A major catalyst for increased competitive pressure are also advances in communication and information technology, creating new forms to conduct business in this industry. Remote membership, electronic order book trading, alternative trading systems, and the internalization of order flow by financial intermediaries all became viable threats to the core business of stock exchanges, i.e. the traditional floor trading activity.

Furthermore, the trading members of the exchanges have become increasingly heterogeneous in nature. On the one hand, they differ in the activity they perform at the exchange. As an example one should think of brokers, dealers or broker-dealers, each with diverging preferences on exchange-related issues such as the imposed fee structure or the investments undertaken. On the other hand, members also vary in size and the scope of activities outside the exchanges. Some banks, for example, are engaged in activities such as over-the-counter trading, derivatives trading and post-trading services. To the extent that exchanges were also active in these fields, they became competitors of the exchanges.

Increased competition and divergence in the interests of the trading members led to a decline in the prosperity of stock exchanges. Some of them arrived at a point where their viability was at stake. In many cases, this resulted in a restructuring of their governance system, a process which is usually denoted as *demutualization*. As a consequence, their organizational form converted from the traditional mutual structure towards a regular outsider-owned, for-profit corporation. Take as an example the New York Stock Exchange (NYSE), whose seat price, a proxy for the profitability of possessing a licence to trade on the Big Board, declined sharply in the last years because of ever-growing pressure from competing trading venues and its members' resistance to implement a modern trading platform. Recently, the NYSE announced its demutualization and the successive migration towards electronic trading. Since March 2006, the exchange has floated its shares on its own market.

Meanwhile, new business opportunities emerged, partly due to the same technological advances that threatened the exchanges' core business. Exchanges could for example embrace the new IT technology to modernize their trading and information dissemination systems. This promised lower transaction costs and potentially higher rents for their members. Furthermore, related business activities that offered both growth opportunities and new sources of income induced exchanges to diversify into these fields. Vertical integration of post-trading services, for example, was easier to accomplish with the availability of modern IT-systems and promised efficiency gains due to straight-through-processing possibilities. The strong growth in the derivatives market induced many exchanges to horizontally integrate this business field by offering a derivatives trading platform.

Hence, the industry seems to experience both a trend towards demutualization and diversification into related business activities. Figure 4.1 confirms this notion for the 50 largest stock exchanges that report to the World Federation of Exchanges (FIBV). The left panel shows the number of exchanges according to their governance regime for the years 1999 to 2003. It becomes clear that the number of exchanges that are organized as mutuals, or are state-controlled, decreased substantially from 40 to only 25. In the same time period, the number of demutualized exchanges has increased from 10 to 25. Note that we distinguish between demutualized and publicly listed exchanges. The main difference between the two groups is that the latter not only underwent a demutualization process, but also sought a public listing. This will be relevant in the following, as the two groups differ in the type of owners they possess.

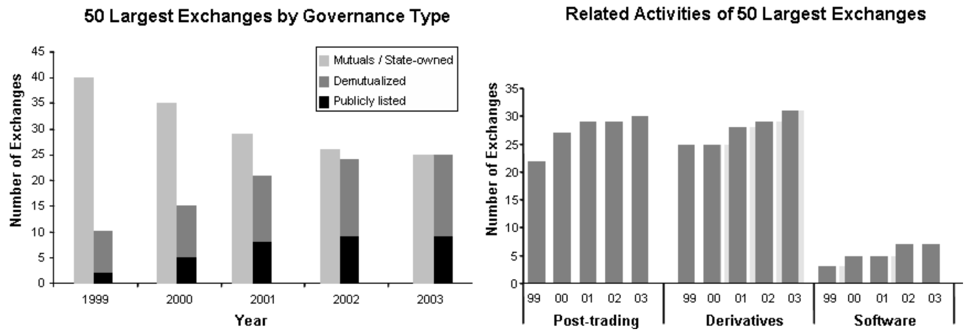

Figure 4.1: Organizational Form and Diversification of Stock Exchanges 1999-2003

The right panel shows the increase in diversification activity for the same sample of exchanges. The number of exchanges that added post-trading services to their business portfolio rose from 22 to 30, while the number of entities that operate a derivatives trading platform marked up from 25 to 31. Despite the strongest relative increase, providers of software solutions remained rather scarce, with three exchanges offering this service in 1999 and seven in 2003.

A preliminary event-study An obvious question seems whether there is a link between the two trends. One could argue that, since demutualized exchanges are profit-oriented entities, they are more likely to invest into related business segments to increase their revenues (and possibly profits, too). Figure 4.2 seeks to provide some preliminary empirical evidence by presenting two small 'event-studies'. We compare both the average degree of diversification and the development in operating revenues of exchanges that underwent a governance restructuring with entities that remained organized as mutuals. Without laying out the full details of the employed methodology at this point - we provide a detailed description in appendix B.6 - the graphs make clear that the change in governance, especially for exchanges that went public, did have a profound effect on both dimensions.

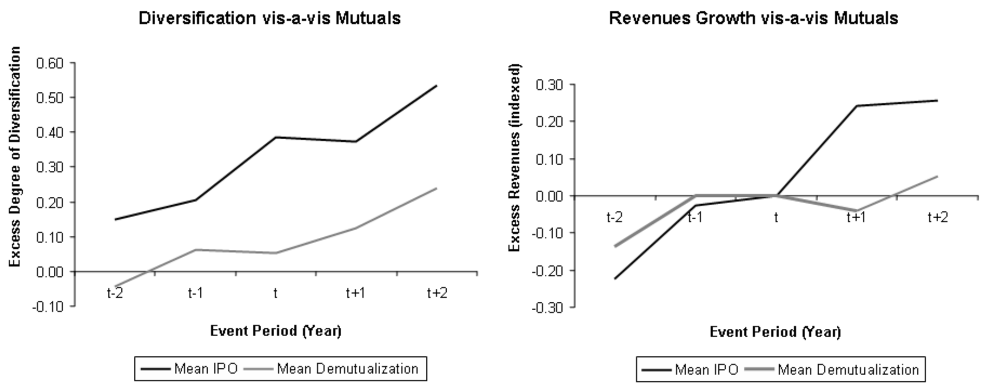

Figure 4.2: Event Studies on Governance Changes

The left graph shows that the average excess degree of diversification increased after the event of demutualizing and going public in period t, where one period equals one year, respectively. Note that exchanges that experienced such an 'event' have already been more diversified on average than the control sample of mutual exchanges prior to the event. This can be seen by the fact that both lines are in positive territory in period t-1. However, as our graph indicates, we still witness a significant rise in our measure after the event period.[1]

The right graph provides a somewhat similar picture, especially for publicly listed exchanges. Here, the indexed development in operating revenues for exchanges that either demutualized or went public are adjusted for the development in revenues of the control group of mutuals. As can be seen, publicly listed exchanges have outpaced their mutual counterparts on average after their respective IPO (at period t), whereas demutualized exchanges did not experience any significant excess rise in their revenues. We argue that the lion's share of the increase in revenues stems from these new related activities. Although one could propose that exchanges may have also earned more from the traditional cash market operation, our data lends only limited support to this notion.[2]

Our contribution and main findings The purpose of the first part of the paper is to provide a theory that explains the diverging investment behavior of exchanges and trading platforms[3] with different governance regimes. To model this, we build on a simplified version of Rey and Tirole (2000) which we adapt and extend to certain characteristics of stock exchanges. In a static model, we analyze the competition between stock exchanges and their investment behavior. In our basic setup with homogeneous users, both competitors are considering to invest in an innovation which improves their trading technology and provides uniformly distributed benefits to all users. The investment is value-enhancing for their users, if the (fixed) costs can be recouped by charging a transaction fee on a sufficiently large trading volume. We show that in competition with an outsider-owned stock exchange, the mutual exchange is typically at a disadvantage. Our argument is mainly based on the idea that the latter has no financial buffer provided by outside investors and therefore has to pass on its investment costs to its members, irrespective of the trading volume that remains on its platform. Consequently, the mutual exchange is exposed to the possibility of runs, as a member's exit exerts a negative externality on the remaining members. We show that, in most circumstances, the outsider-owned exchange can exploit this fragility, thereby undermining the ability of the mutual exchange to invest, despite the existence of a countervailing "second-sourcing"-effect, which supports the investment propensity of a mutual. Second-sourcing connotes a situation where the mutual exchange invests into the project, even though it knows that its members will migrate to the competing for-profit exchange. The reason for this is that the mutual can improve the price conditions of the transfer for its members by investing into the project.

Introducing heterogeneity of members into the model confirms our results, when a majority of members experience a negative externality from the investment project.[4] We argue that this extension of the model structure should be interpreted as investments in related non-core business activities of an exchange, whose potential benefits are not distributed evenly across

[1] Note that some of the exchanges that underwent the demutualization process are also part of the IPO-sample as they went public a short period of time after their demutualization. Thus, the IPO-means partly show the development of the very same demutualized exchanges, which however, does not affect the validity of our statement advanced here.

[2] There has been an exceptional rise in revenues from cash trading-related activities by some smaller exchanges. Oslo Exchange, for example, increased its trading-related revenues from 1999 until 2004 by more 80%, the Wiener Börse by even 350% in the same time period. Yet, for the majority of the exchanges in our sample, we did not observe a significant rise in cash-trading revenues.

[3] We will use the terms trading platforms and exchanges synonymously.

[4] If a majority of members benefits from the project, we interestingly observe a higher investment propensity than for the case with homogeneous users, albeit lower than at an outsider-owned exchange.

different types of members. This aspect of our model has important practical implications, as industry participants are concerned about certain investments undertaken by exchanges, such as the vertical integration of post-trading services, which are profitable for the exchange, but may be detrimental to its users. In Europe, outsider-owned Deutsche Börse, which bought post-trading services provider Clearstream in 2003, is therefore under particular scrutiny by both users and regulatory authorities due to fears of anti-competitive behavior.[5] The results from our model underline the fact that outsider-owned exchanges are less constrained in their investment behavior, which could lead to overall welfare losses, if the negative externalities borne by the users are larger than the gains for the exchange and its owners.

Furthermore, we will extend our basic model to a dynamic setting to analyze the options of an incumbent mutual exchange to survive in a competitive environment. To answer this question, we incorporate a standard overlapping generations framework into our model. This allows us to investigate the viability of a mutual exchange, which competes against an outsider-owned exchange. We show that when experiencing fierce competition from a for-profit trading platform, a mutual exchange can only survive if it converts to a similar governance regime. This result hence provides a rationale for the recent wave of demutualization amongst exchanges that were exposed to increased competitive pressure.

In the second part of the paper we present empirical evidence for the main results derived from our model. For that purpose, we hand-collect information on the business model, competitive situation and governance regime for a sample of 26 stock exchanges in the time period 1999-2003. We then formulate two hypotheses that are linked to the main predictions from our theoretical part: Our first hypothesis tests whether competitive pressure increases the likelihood of demutualization, whereas our second hypothesis evaluates whether demutualized exchanges are more likely to invest in non-core business activities. In order to account for potential endogeneity problems between our governance, competition and business model variables, we use bivariate Probit regressions that simultaneously estimate our two hypotheses. Our results provide strong support for our stated hypotheses.

Related literature Our paper is related to different strands of the theoretical and empirical literature. First of all, the theoretical literature on mutuals and cooperatives is relevant. However, due to the large volume of contributions, we will merely be able to discuss selected contributions that are closely related to organizational forms of stock exchanges.[6]

One of the most cited papers in this area is by Hart and Moore (1996) (see in addition Hart and Moore (1998) for a more general approach). Focusing on the user welfare of different governance setups for stock exchanges, the authors analyze the relative merits of a mutual structure and outside ownership in dependence of the level of competition and the diversity of member interests. They obtain two main results: (1) Outside ownership becomes more efficient than a mutual structure as the members of the mutual become more diverse in terms of preferences. (2) Outside ownership becomes more efficient than a mutual structure as the exchange faces more competition. In contrast to our theoretical approach they do not explicitly analyze competitive interaction between stock exchanges with different organizational forms, nor do they investigate dynamic considerations that concern the viability of stock exchanges under competitive pressure.

Pirrong (2000b) takes a different approach to analyze governance issues. In contrast to

[5]Several academic contributions have addressed this issue. Confer for example Tapking and Yang (2004) and Köppl and Monnet (2003).

[6]For a very impressive analysis of cooperatives in general, see Hansmann (1996). Holmström (1999) and Fulton (1999) provided more recent, theoretically inspired contributions.

Hart and Moore (1996), he does not compare different owners of the exchange, but focuses on different types of users that may organize their stock exchange either as a for-profit or as a not for-profit entity. He then describes governance mechanisms to mitigate conflicts of interests between the members. In Pirrong (1999) and Pirrong (2002), an analysis of competition between stock exchanges is provided and is based on switching costs and liquidity effects, respectively. In contrast to our analysis, these papers do not deal with the issue of investment incentives and they do not consider explicitly competition between different organizational forms.

Our theoretical analysis has similarities to the theoretical analysis of two-sided markets (see Armstrong (2005) and Rochet and Tirole (2005) for an overview). Furthermore, we build on two contributions by Patrick Rey and Jean Tirole, who analyze similar effects to the one described here in the payment card industry.[7] We adapt this approach to the stock exchange industry and extend their analysis in certain aspects. In particular, we explore investment decisions which have a heterogenous impact on the welfare of stock exchange users. We also investigate in more detail the investment incentives of different organizational forms and their viability under competitive pressure in an overlapping generations framework. In addition, based on the global games framework developed by Carlsson and van Damme (1993), we provide an analysis of the fragility of mutual exchanges that incorporates coordination problems of the exchanges' members.

The number of empirical papers on the governance of stock exchanges is relatively small. Krishnamurti, Sequeira, and Fangjian (2003) analyze the market quality of exchanges with different organizational form. They find evidence that the demutualized National Exchange of India provides a higher market quality than the mutual Bombay Stock Exchange. Mendiola and O'Hara (2003) focus on the post-IPO performance of publicly listed exchanges and find that these exchanges outperform both the general market and other IPOs. Furthermore, they find evidence for a positive link between the fraction of equity sold to outside investors and stock exchange performance. Yet, their findings are confined to the group of publicly listed exchanges and cannot provide any comparison to exchanges that are not outsider-owned. Other empirical attempts to compare different governance regimes in the stock exchange industry mainly rely on frontier efficiency methods. While Schmiedel (2001) employs a parametric stochastic frontier model to evaluate the cost efficiency of European stock exchanges, he applies a non-parametric method in a second paper (Schmiedel (2002)). The former paper controls for demutualized exchanges within the regression and displays a positive impact of demutualization on cost efficiency.[8] In his second paper, the mean of factor productivity gains is higher among mutual exchanges.

A recent paper by Ramos (2005) employs univariate Probit regressions to evaluate the propensity of exchanges to demutualize. It finds evidence that competitive pressure has a positive effect on the likelihood of exchanges to demutualize. Our paper has most similarities to the analysis of Ramos (2005) as we will also conduct Probit regressions to analyze the influence competition has on the decision of exchanges to demutualize. However, we need to employ a more involved estimation technique. As we also seek to provide evidence for the impact of organizational forms on investment decisions at exchanges, we use a bivariate Probit approach to account for potential endogeneity issues stemming from our governance variable.

The paper is structured as follows. Section 4.2 presents our model and states our propositions. Section 4.3 formulates the hypotheses, which we want to test, discusses the data and methodology employed, and finally presents our empirical results. Section 4.4 concludes.

[7] See Rey and Tirole (2000) and Rey and Tirole (2001). Rochet and Tirole (2002) provides a very interesting analysis of the competitive structure of the payment-card industry.

[8] Confer Schmiedel (2001, p.22)

4.2 Model

4.2.1 The basic setup

Competition, trading volume and users We are considering two exchanges X_1 and X_2, which both operate a proprietary trading platform. Initially, each of them has the same (large) number of identical users. We normalize the number of the users to a continuum of mass 1, such that we have customers of mass 2 in this economy, equally distributed on both systems.[9] We assume that the exchange's respective customers have made platform-specific investments in the past in order to access the trading venues. Therefore, we consider each exchange's customers as its respective installed base. These customers can be dealers, brokers, dealer-brokers, and banks, who use the trading platform of the exchange to execute trades for themselves and/or on behalf of the investing public.[10]

Initially, both exchanges have the same size in terms of trading volume, i.e. their customers generate a total trading volume of $v > 0$, respectively, which cannot be moved to another trading platform. To introduce competition in our model, we assume that the users possess an additional trading volume k, which can be transferred to the rival exchange without switching costs. We interpret this as the growth in trading volume. Hence, the higher the ratio k/v, the higher the degree of potential competition between X_1 and X_2. By introducing a fixed and a transferable component of trading volume, we want to grasp home-bias effects and other restraints in our model, which typically limit the degree of competition in the stock exchange industry.[11] This is due to the stickiness of trading volume at platforms that offer the highest level of liquidity in a certain security and which makes it very difficult to transfer it to a new exchange.

Investment project The trading costs that are incurred will determine the competitiveness of stock exchanges. To fix ideas, let us assume that, initially, both exchanges possess per unit transaction costs equal to c. In addition, both exchanges can invest in a project with fixed investment costs I and a gross surplus of θ for each user.[12] We assume that the following investment condition holds:

$$v\theta < I < (v + k)\theta. \tag{4.1}$$

This condition states that the investment should be undertaken if an exchange not only attracts the fixed base volume v, but also at least the transferable volume k of its own users. However, the investment is not profitable if the exchange only retains the fixed volume v. We have chosen a general formulation for the gross surplus θ from the investment project, since the investment opportunity will be interpreted in different ways. For instance, it could be viewed as a technical

[9] In the following, the terms "customers" and "users" of a stock exchange are synonymously.

[10] We do not explicitly analyze competition effects among the customers in the "downstream" market for the end-users of the exchange, e.g. retail traders and non-financial companies. In that respect we are quite agnostic. To simplify matters, we assume that trading volume and rents of the users will not be influenced by the trading fees charged by an exchange. Since we are not considering social welfare aspects and our main focus lies on the analysis of competition among exchanges, our results go through as long as we have some market imperfections on the end-user market. See Hausman, Leonard, and Tirole (2003) for an in-depth analysis of competition effects in the credit-card industry in a "double-differentiation" framework with systems differentiated as in Hotelling's model and end-users, i.e issuers, differentiated as in the Lerner-Salop model.

[11] Many countries just have one national stock exchange with an overwhelming market share in the trading of domestically listed companies. In these cases, competition comes merely from foreign exchanges, OTC-trading and intermediaries that internalize client orders.

[12] In the basic model, we assume that there are no differences among the exchanges in the surplus of the available investment projects. However, this does not imply that the investment projects are necessarily identical. Instead, each project is adapted to the trading technology the respective exchange uses. With this assumption we want prevent that our results are biased by the nature of the project.

improvement of the exchange's cash trading operations (e.g. its trading technology) such that the trading costs c are reduced by $\theta = c - c'$. Alternatively, the investment could take place in related business activities as described in the introduction, thereby producing less specified *rents* $(v + k)\theta$, which we assume to be proportional to the trading volume as well. However, there is one distinction between the two types of investment projects: Typically, the former investment project has a *homogeneous* influence on the users such that each user can potentially gain θ per trading unit. The latter investment opportunity, on the other hand, may have a *heterogeneous* impact in the sense that the distribution of rents is not uniform across all users. This captures the notion that an investment into related activities may create different externalities on the business activities of the various types of users (e.g. brokers, dealers, or banks). Thus, while $(v + k)\theta$ still represents total surplus, for different user-groups j, the impact θ_j may vary. Consequently, our notation in this case will be $\sum_{j=1}^{n} y_j\theta_j \equiv E[\theta] = \theta$, with y_j denoting the mass of the user-group j in the whole population of users of the exchange and the expected surplus equaling to the θ, as in the homogeneous case. We assume the θ_j's to be private information of each user, while the composition of θ is common knowledge.[13]

Characteristics of organizational forms Our model considers two exchanges that compete for the transferable trading volume of their members. The exchanges are either organized as not for-profit, member-owned mutuals or as outsider-owned, for-profit firms. There are three stylized distinctions between the two organizational forms:

1. Control structure: In the case of a mutual exchange, the customers/members are also the owners of the exchange and take decisions according to a democratic one-member, one-vote scheme. Hence, the mutual exchange acts in the customers' interest by maximizing their expected benefits. As long as the impact of the considered investment is homogeneous for all members, the decision of the exchange is taken unanimously. In case of heterogeneity, which we model in the simplest possible way with two types of users, i.e. y_j with $j = h, l$, the decision rights rest with the member group y_j that possesses the majority.[14] In contrast, an outsider-owned, for-profit exchange acts in the interest of its investors and does not take into account the potential externalities that may emerge for the exchange's customers. Outside owners are exclusively interested in the profitability of a project and will decide accordingly.

2. Price discrimination: Mutuals cannot discriminate among their members in terms of the trading fees. In contrast, outsider-owned exchanges are not constrained in the use of price discrimination. They may charge different prices for different customers.

3. Access to finance sources: A mutual's budget must be balanced ex post, regardless of the volume allocated to its trading platform, as it operates on a break-even basis and cannot make use of outside capital. Since the costs of a potential investment have to be financed via trading fees, the mutual exchange will set the transaction price according to the trading volume that was generated on its platform. Such a financing mode starkly contrasts with that of an outsider-owned, for-profit exchange, which can rely on the cushion provided by equity and long-term debt, if the costs of the investment project exceed the amount of received trading fees.

[13] By incorporating heterogeneity and private information into the model, our model has features of the model by Hart and Moore (1996).

[14] For the general case with several types of member interests, the median voter-rule should be applied.

Time structure of investment decisions Our time structure will be typical for a long-term investment, which needs "time to build". Our model has three time periods:

Time period 0: The exchanges decide whether to undertake an investment and announce their trading fee level a to be charged in period 2.

Time period 1: The customers of the exchanges non-cooperatively decide where to allocate their transferable volume k.

Time period 2: The projects, if taken, are realized. The exchanges charge their trading fees.

Due to the different financing patterns outlined above, the time structure will have the following important implications: (1) A mutual that is considering to invest into the project has to bear in mind that the project's attractiveness critically depends on whether its users channel their additional trading volume to the exchange. A diversion of volume by some members to a competing exchange would leave the volume of the remaining members exposed to larger trading fees, as the fixed costs of the project have to be financed exclusively by this source. This in turn may trigger further diversion of trading volume. As the trading fees will be determined by the budget balance constraint, negative network externalities and coordination problems emerge. Consequently, the mutual exchange cannot bind itself to its announcement a in period 0 and is therefore exposed to runs.[15] In essence, irrespective of what it announces in period 0, its fee will ultimately be determined by the retained volume in period 2. (2) The for-profit exchange on the other hand can credibly commit to its announcement in time period 0, as its outside investors serve as residual claimants if an unexpected event arises, such as insufficient trading volume, which needs a financial buffer. In essence, the varying financing patterns introduce different degrees of *commitment* to the announcement of trading fees to the model. This creates a competitive edge for the outsider-owned exchange, which we will outline in the following sections.

Structure of the theoretical part of the paper Given this setup, in section 4.2.2.1, we analyze how a mutual's investment behavior is affected by different competition scenarios. Thus, we evaluate its propensity to invest when it faces competition for the transferable volume k from no other exchange, another mutual, and an outsider-owned exchange. We will initially focus on an environment with homogeneous users, so that the undertaken projects are interpreted as investments into the core business activity of exchanges, i.e. the cash trading business. In section 4.2.2.2, we analyze the same question with respect to investments in related activities, which have a heterogenous impact on users. Section 4.2.2.3 concludes our analysis of the static case by presenting the results graphically. In section 4.2.3, we enrich our basic setup with a dynamic overlapping generations model to investigate the long-run viability of a mutual exchange that competes against an outsider-owned exchange. Propositions at the end of each section summarize our findings.

[15] The bank run literature presumes a similar investment pattern, for instance in the seminal paper of Diamond and Dybvig (1983). Hence it comes at no surprise that coordination failure and multiple equilibria build the core aspect of these models. As we will see later on, this will also be an important issue in the model presented here.

4.2.2 The static model - Investment propensity of exchanges

4.2.2.1 Competition between stock exchanges with homogeneous users

No competition As an introductory case, we briefly describe the situation, where neither exchange has the possibility to attract the transferable volume k from the customers of the rival exchange, i.e. when the exchanges face no competition. In this case, each exchange will invest into the efficiency-enhancing technology, as it knows that it will receive the transferable volume k with certainty. According to condition (4.1) the investment is worthwhile for each exchange delivering a surplus of $\theta(v+k)-I$. In case of two mutual exchanges, this means that the trading costs will be lowered to

$$\hat{a} \equiv c - (\theta - \frac{I}{v+k}) < c. \tag{4.2}$$

Competition between two mutuals More interesting is the case in which two mutual exchanges are competing for the total transferable volume $2k$ of their customers. Which equilibrium will result and what will be the critical investment cost threshold? Each exchange will decide to invest at time period 0 if it expects its own customers to leave volume k on its platform in period 1. This will be the case, if a member/user of an exchange has no incentive to reallocate its volume. Hence, the following condition must be satisfied:

$$\hat{a}(v+k) \leq cv + \underline{a}k \tag{4.3}$$

with $\underline{a} \equiv c - (\theta - \frac{I}{v+2k})$ defined as the trading costs if one of the exchanges manages to attract the transferable growth volume of both exchange users. On the left hand side, we have the trading costs for a customer when it sticks to its exchange, while the right hand side displays the average trading costs when it transfers its volume to the exchange, where $2k$ is traded. Inserting for $\hat{a}$ and $\underline{a}$ from (4.2) and (4.3), we get the following condition:

$$I \leq \frac{\theta v(v+2k)}{v+k}. \tag{4.4}$$

Let us denote I_m as the investment cost threshold of a mutual that competes against another mutual, defined as the costs where condition (4.4) is satisfied with equality. We can see from condition (4.4) that the growth trading volume k has a positive impact on the users' loyalty to their original exchange. The higher k, the more likely condition (4.4) is fulfilled so that it is in the interest of customers not to shift their trading volume. Intuitively c.p. a higher k means that the investment project generates a higher net present value for the users. Given our fixed investment costs I and the fact that the investment of the "home"-exchange also has a positive impact on the non-transferable trading volume v, a high net present value of the investment will induce each individual user to prefer its own exchange to invest. In contrast, investments, which have just a marginally positive net present value, will be undertaken by only one exchange, albeit it is not clear which exchange will be the investing one in such a symmetric case. However, introducing a small commonly known productivity difference between the exchanges into the model would favor the more productive exchange to invest, if it is common knowledge that the users can coordinate on the Pareto-dominant action. For now, we assume this to be the case, however we will discuss the issue of equilibrium selection in more detail at a later stage (see also the analysis in Appendix B.2).

Competition between a mutual and an outsider-owned exchange Let us now analyze the situation when a mutual exchange faces competition from a for-profit, outsider-owned exchange. For notational convenience, we assume that X_1 is organized as a mutual and X_2 as a for-profit exchange controlled by outside investors. Given our assumption on the varying degrees of commitment between the two organizational forms, the outsider-owned exchange does not need to be concerned with the risk to lose k of its own users to X_1. As we will show later, this will always be the case in equilibrium as long as the outsider-owned stock exchange invests. We will therefore start with the assumption that X_2 always obtains the loyalty of its users.[16] Given that X_2 invests, what are the alternatives for the mutual exchange?

Let us first suppose that the mutual declares not to invest in time period 0. In this case, the members of X_1 will transfer k to X_2, as the latter will offer a trading fee that is at least as low as at X_1, i.e. c. Since X_2 maximizes its profits, it will just offer $a_2 = c$.[17]

Alternatively, both exchanges may announce to invest. Under the assumptions we made, the mutual exchange is most attractive when all its members stay loyal and trade the transferable volume k at their home-exchange, which would result in fees amounting to $\hat{a}$. However, they would transfer k to X_2 if and only if

$$a_2 k \leq \hat{a} k. \tag{4.5}$$

Accordingly, it is Pareto-dominant to remain loyal as long as $a_2 > \hat{a}$. However, in case of an equally good offer, the users of X_1 will switch. Hence, X_2 will attract the new volume if it offers

$$a_2 \leq \hat{a} \equiv c - (\theta - \frac{I}{v+k}). \tag{4.6}$$

Note that it is indeed profitable for X_2 to make such an offer, since it can potentially serve the customers at marginal cost $c - \theta$ and can gain revenues from this offer which are strictly higher than the marginal costs according to condition (4.6).[18]

Interestingly, even though the mutual exchange is at a disadvantage to retain the volume of its own members, let alone to attract new customers, we may still observe that it invests in the project. The rationale for this is that the *terms* of X_2's offer for the members of X_1 can be influenced to their advantage due to the positive strategic effect that emerges when X_1 also invests: Knowing that X_2 will invest, the members of X_1 anticipate the offer at transaction costs c in case X_1 does not invest. Therefore, members of X_1 could consider to take the investment at their own exchange and still divert their trading volume k to X_2. By doing so, the members of X_1 may force exchange X_2 to improve trading conditions from c to $c - \theta$.

To see this, consider the alternatives of the members of X_1: They will compare the costs of

[16]To support this equilibrium, one only needs the out-of equilibrium beliefs that the outsider-owned exchange would offer favorable terms to users who want to depart to the mutual exchange.

[17]We assume that in case of an equally attractive offer, the original users of an exchange are curious and do not stay loyal to their home-exchange. Thus, X_2 merely has to offer conditions that are at least as good as their home exchange for attracting their new customers. This convention, which is without loss of generality, will be adopted to solve the "openness problem" common to Bertrand games.

[18]Furthermore, even if the investment project of the outsider-owned exchange is not as productive as the investment project of the mutual exchange, the former exchange will succeed in getting the growth volume of all users as long as the difference in productivity is not too large. To see this, let us assume that the investment costs of the projects I_i for both exchanges are equal, $I_1 = I_2 = I$, but the return of the investment θ_i is larger for the mutual exchange, i.e. $\theta_1 > \theta_2$. Inserting $a_2 = c - \theta_2$ and $\hat{a} = \hat{a}_1 = c - \theta_1$ in condition (4.6) for a success of the outsider-owned stock exchange, we observe that

$$c - \theta_2 \leq c - \theta_1 + \frac{I}{v+k} \Leftrightarrow \theta_1 - \theta_2 \leq \frac{I}{v+k}.$$

Again, the lower θ the more easily will this condition be satisfied. Technologically inferior investments by an outsider-owned exchange will be undertaken in competition with an mutual exchange because of a stealing effect that gains momentum due to the differences in the competitors' underlying organizational forms.

not investing with those of investing, provided that they will divert k in any case. Hence, the costs will be $cv + a_2k$ in the case of not investing. As already mentioned, X_2 does not have to make an offer a_2 below c so that the second summand will be equal to ck. In the case of investing, the costs would amount to $cv + I - v\theta + \hat{a}k$. Note that according to our assumption on the profitability of the investment project, I is always larger than $v\theta$. Hence, if

$$cv + ck \geq cv + I - v\theta + \hat{a}k, \tag{4.7}$$

which after inserting for $\hat{a}$ and collecting terms can be written as the investment condition

$$I \leq \frac{\theta(v+k)^2}{v+2k}, \tag{4.8}$$

the mutual exchange will invest, notwithstanding that it only serves the base volume v. I_{oo} denotes the investment cost threshold where this condition is satisfied with equality in the case when a mutual competes against an outsider-owned exchange. Taking the derivative of condition (4.8) with respect to k, one can see that, in equilibrium, the mutual exchange invests, if k is relatively large compared to v, i.e. if the competitive pressure is high, given our measure k/v. Hence, it is in the interest of X_1-members to invest when the size of the transferable volume is large. In such a case, they benefit from the better cost structure of the investing mutual exchange, since this will improve the conditions to which they can trade k on X_2. Notice the similarity of this argument to strategic models of "second-sourcing" in the tradition of Farrell and Gallini (1987) and Shepard (1987) who show that second-sourcing can be interpreted as a commitment device to protect buyers' interests against a monopolistic supplier's ex post opportunistic behavior. In our Bertrand competition model, the mutual exchange - working in the interest of its members - fulfills quite a similar role.

Comparison of investment propensities We have seen that due to the possibility to credibly commit to a certain fee level, for-profit exchanges will always invest in the efficiency-enhancing project. In fact, as the outsider-owned exchange always succeeds to attract the transferable volume of the mutual exchange k in equilibrium, it knows that its total trading volume is not only $v + k$ but adds up to $v + 2k$. Therefore the gross surplus resulting from the additional volume amounts to $k\theta$. As we have shown in the last section, a part of this rent has to be given to the new users because of the second-sourcing effect. However, the remaining part can be appropriated by the outsider-owned exchange, and this, in turn, will strengthens its investment incentives further. Hence, its investment boundary I_{FP} is

$$\theta(v+k) \leq I_{FP} \leq \theta(v+2k). \tag{4.9}$$

The mutual, on the other hand, lacks this characteristic and will therefore invest less heavily. What we still have to provide an answer for, though, is how the investment propensity of mutuals depends on the governance regime that the competing exchange possesses.

To see whether an exchange, organized as mutual, has a *higher* propensity to invest when it faces competition by an outsider-owned platform or by another mutual exchange, we compare the respective investment hurdle rates of X_1. Therefore, if we presume that I_{oo} is greater or equal to I_m, and replace the investment boundaries by the respective right hand sights of conditions (4.8) and (4.4), we obtain the following inequality:

$$\frac{\theta v(v+2k)}{v+k} \geq \frac{\theta(v+k)^2}{v+2k}. \tag{4.10}$$

Simplifying (4.10), we obtain the result that as long as

$$\frac{k^2}{v^2} - \frac{k}{v} \leq 1, \tag{4.11}$$

i.e. the level of competition expressed as $\frac{k^2}{v^2} - \frac{k}{v}$ is less or equal to one, the investment cost threshold, and propensity by same token, of a mutual will be larger, when competing against another mutual exchange. This holds as long as k is not significantly larger than v.[19] For transferable volumes significantly larger than the invariable amount, on the other hand, a mutual will have a higher propensity to invest when facing competition from an outsider-owned exchange. Therefore, if the degree of competition is very high among trading platforms, a mutual is more inclined to invest in efficiency-boosting modernization projects, if the competing counterpart is organized as a for-profit exchange. The reason for this rests on the dual-sourcing argument outlined earlier, which makes investments more likely, but which are only relevant when competing against a rent-seeking outsider-owned exchange.

Note that we have so far considered situations, where the for-profit exchange treats all potential new customers from X_1 equally in the sense that the announced transaction costs are non-discriminatory for different customers or customer groups. However, in principle, exchange X_2 could make discriminatory offers to the members of the mutual exchange, if this proves to be profitable. As we analyze in appendix B.1, this divide-and-conquer strategy leads to a *snowballing* effect at the mutual exchange, resulting in a shift of the transferable volume k to the outsider-owned exchange. Therefore, while this result is skewed in favor of outsider-owned exchanges, the introduction of discriminatory offers also liberates our analysis from the assumption of the Pareto-dominance criterion, since the divide-and-conquer strategy deters coordination by the members of the mutual exchange. For our basic model, however, we will alleviate this strong assumption by analyzing our setup in a global games framework in the following.

Multiplicity of equilibria So far, by adopting the Pareto-dominance criterion we have assumed that the members of the mutual exchange can coordinate on an equilibrium to the best of their *common* interest. Naturally, this is not the only possible equilibrium. As usual in coordination games like ours, multiple Nash equilibria are possible. Thus, we will analyze whether we can get rid of the multiplicity of equilibria and specify precisely the parameter values of the model for which members choose to move their transferable volume to the outsider-owned exchange. This would allow us to provide a comparative statics analysis of the factors that influence this decision, without imposing somewhat arbitrary assumptions regarding the behavior of the members.

To deal with this issue, we draw on the *global games* approach to find a unique equilibrium.[20] This approach builds on the idea that individual players, in our case the members of the exchange, are facing payoff uncertainty, which is caused by an underlying state of the economy. In our framework, this would correspond to uncertainty regarding the productivity parameter of the investment technology θ. Introducing this type of payoff uncertainty into the analysis, it can be shown that members, behaving individually optimally, will not be able to coordinate their actions on the Pareto-dominant equilibrium. Instead, in dependence of the underlying state, a unique equilibrium will always result. Typically, the resulting equilibrium will be the

[19] In fact, the result holds as long as k is smaller than approximately 1.6 times v. Confer also section 4.2.2.3.

[20] See Carlsson and van Damme (1993) for a first illustration of this theory and Morris and Shin (2003) for a recent survey and full analysis of global games. The illustration chosen in appendix B.2 follows closely Allen and Morris (2001) and Myatt, Shin, and Wallace (2002).

risk-dominant one, using the terminology of Harsanyi-Selten.

However, this equilibrium always implies some coordination failure among the members.[21] In our framework, the risk-dominant equilibrium corresponds to the outsider-owned exchange X_2 setting an offer $\breve{a}$, with $a_2 < \breve{a} < \hat{a}$, such that the trading costs are slightly lower than

$$\breve{a} \equiv c - (\theta - \frac{I}{v + \frac{k}{2}}). \tag{4.12}$$

The condition shows that, because of the coordination problems of the members, the outsider-owned exchange will attract the members of the mutual exchange quite easily, even if it cannot use discriminatory offers, which we outlined in detail in appendix B.1.[22] Hence, coordination problems on part of the mutual's members reinforce the competitive edge of the outsider-owned exchange. We provide a detailed analysis in appendix B.2.

Summarizing the analysis of this section so far, we formulate the following proposition:

Proposition 1 *With homogeneous users we obtain the following results:*

1. *In a competitive environment with two mutual exchanges, both will invest, provided condition (4.4) is satisfied. For increasing values of k the condition is more likely to be fulfilled. In case of an investment project with only marginally positive value, only one exchange will invest.*

2. *In a competitive environment with one mutual exchange and one outsider-owned exchange, the latter has a competitive edge and a higher propensity to invest, even if its investment project is somewhat less efficient. However, under certain conditions, the mutual exchange will invest in the new project, even though it will not retain k on its platform in order to improve its members' bargaining position vis-à-vis the outsider-owned exchange.*

3. *The competitive advantage of the outsider-owned exchange over the mutual exchange increases if the outsider-owned exchange uses discriminatory offers. Additionally, the competitive advantage is higher when the members of the exchange cannot coordinate their actions.*

4.2.2.2 Competition between stock exchanges with heterogeneous users

One important assumption of our analysis so far was that all users are homogeneous. However, some investment projects of stock exchanges may have a diverse impact on their users. If one thinks about investments in non-core business activities such as derivative trading, post-trading activities and software sales, it is plausible to assume that these activities will afflict stock exchange user groups, i.e. brokers, broker-dealers, investment banks and commercial banks, in different ways. Thus, we incorporate heterogeneity into the model to analyze these kinds of investments. We will do so in a very simple and stark way by postulating that the investment decision has a heterogeneous influence on the gross surplus θ which different users of the exchange can extract. We thereby shortcut many interesting dimensions of these projects, which may also influence the investment decision.

However, in line with the description of investment projects we are considering, one should interpret θ as an externality exercised on the businesses of the users by the exchange's investment

[21] Not only the global games literature is in support of the risk dominance criterion. Also the evolutionary stochastic adjustment dynamics literature, typified for example by Young (1993), provides independent theoretical justification for the selection of risk-dominant equilibria.

[22] Interestingly, the offer generates approximately the same profit for the outsider-owned exchange as the optimal offer structure when employing a divide-and-conquer strategy (see equation (B.3)).

decision. We will assume that authority matters in the sense that the investment decisions will be taken by the majority of owners of the exchange. Furthermore, each individual θ_j is *private* information of user group j, however, the distribution of θ is common knowledge.[23]

In the following we focus on the interaction between a mutual exchange X_1 and an outsider-owned exchange X_2. To present the argument in the most simple form, we assume that even though the investment is profitable, i.e. $vE[\theta] < I < (v+k)E[\theta]$ holds, the surplus θ merely stems from a fraction of users y_h such that

$$E[\theta] = y_h \times \theta_h \equiv \theta. \tag{4.13}$$

Hence, a fraction y_h of users experiences a positive impact by the investment project, θ_h, while a fraction $1 - y_h$ has no positive influence, $\theta_{1-h} = 0$. To incorporate the flavor of the one-member, one-vote structure that is prevalent at mutual exchanges, we assume that the decision rule regarding the investment project is a simple majority rule. Thus, in case of $y_h \geq 0.5$, the members with a positive impact will take the decision regarding the investment project, whereas it will be rejected for $y_h < 0.5$, as a majority of members would not benefit from the project, but would have to bear its costs. Let us presume that the outsider-owned exchange will invest. We will see later on that, in equilibrium, this will always be the case. Which decision will be taken by the mutual exchange?

In case the fraction y_h of members has a majority in the mutual exchange, the outsider-owned exchange attracts these members, if its offer is

$$a_2 \leq a_h \equiv c - (\theta_h - \frac{I}{v+k}). \tag{4.14}$$

Note that a_h differs from condition (4.6) by the term $\theta_h > \theta$, since the outsider-owned exchange has to make an offer, which matches the unit costs that the members with a strong positive impact can expect, given that the mutual invests. And in fact the mutual exchange, acting in the interest of its members with a positive impact, has a high incentive to invest, because only in this case, they benefit from the "second-sourcing" effect. The mutual exchange will thus invest, if it influences its members' rents positively, i.e. if

$$c(v+k) \geq (c + \frac{I - v\theta_h}{v})v + a_h k. \tag{4.15}$$

The condition for exchange X_1 to invest is hence

$$I \leq I_{ooHet} = \frac{\theta_h (v+k)^2}{v+2k}. \tag{4.16}$$

Therefore, since we have $I_{ooHet} > I_{oo}$, even relatively high investment costs do not deter the mutual exchange from investing in such a constellation. The investment costs will be borne in part by the $(1 - y_h)$-fraction of members who are not positively affected by the investment, an effect which increases the investment incentives of the y_h-fraction of members. On the other

[23] More precisely, in line with the arguments made in Hart and Moore (1998) we are assuming that a firm, which is defined by its non-human assets, has to assign the authority for decisions on the use of assets and investments via its ownership structure, if a comprehensive contract cannot be written ex ante. Hence, in a mutual the decision power rests with the members according to the one-member, one-vote rule. In contrast, in an outsider-owned exchange the investors, which are solely interested in the profitability of projects, possess the control rights and can therefore be considered as homogeneous according to our understanding. Since we assume the surplus from the investment θ_j to be private information, ex post inefficiencies of the investment decisions are possible. It is an open question whether sophisticated mechanisms are possible to recontract these decisions. We assume here, also in line with Hart and Moore (1998), that this is not possible.

hand, the members with no positive direct impact from the investment also profit from the offer a_h made by the outsider-owned exchange, since the outsider-owned exchange cannot distinguish between different member types. By offering a_h to all members for their volume k, it provides in fact a subsidy to the $(1 - y_h)$-members. However, the outsider-owned exchange will still find it profitable to make the offer and invest into the project, since it can serve the additional volume k at marginal costs $c - \theta$. Thus, in equilibrium, the outsider-owned exchange will invest. And again, as already discussed for the case with homogeneous users, the investment propensity of the outsider-owned exchange is always higher than that of the mutual exchange, as the former attracts the users of the latter one.

What happens, when the members with $\theta_{1-h} = 0$ possess the majority? In that case, the mutual exchange will not invest, since the members in charge do not benefit from the investment. The outsider-owned exchange merely has to offer $a_2 \leq c$ to attract the y_h-customers with the positive impact.[24] Summarizing this section we formulate the following proposition:

Proposition 2 *With heterogeneous users we obtain the following results in a competitive environment with one mutual exchange and one outsider-owned exchange:*

1. *The mutual exchange will invest in the project if condition (4.16) is satisfied and members with high value of θ are in the majority. However, the outsider-owned exchange has always a higher investment propensity than the mutual exchange.*

2. *Price discriminating offers do not improve the competitive advantage of the outsider-owned exchange.*

3. *If the members with $\theta = 0$ are in the majority, the mutual exchange will never invest and the outsider-owned exchange has the highest propensity to invest, since it merely has to undercut a quite unfavorable offer by the mutual, which gives the outsider-owned exchange large profit opportunities.*

4.2.2.3 A graphical illustration

To conclude section 4.2.2 and thereby our analysis of the static case, we provide a graphical illustration of our results. Figure 4.3 depicts the investment propensity of exchanges with different governance regimes and competition scenarios. More specifically, for the parameter values $\theta = 1$, $v = 1$ and $\theta_h = 1.5 \times \theta$, we display how the threshold investment costs I (vertical axis) depend on the level of competition approximated by k/v (horizontal axis), for different organizational forms. The areas under the respective graphs represent the feasible regions where the exchanges will invest.

The benchmark case with the highest investment propensity over the whole range is represented by an outsider-owned, for-profit exchange, indicated by the shaded area between the two solid lines denoted as I_{FP}. The outsider-owned exchange will always invest in the project as long

[24] When the outsider-owned exchange is allowed to use discriminatory offers, it can - as shown in appendix B.1 - exploit the externalities between the users of the mutual exchange. However, the optimal divide-and-conquer policy is more difficult to implement and not as effective now due to the heterogeneity of the members and their privately observed information on θ_j. To see this, we need to change the framework slightly and assume that the $(1 - y_h)$-group of user experience a small ϵ-value from the investment project instead of a zero value. Now an outsider-owned exchange cannot use the offer structure depicted in equation (B.2) to implement a snowballing effect, since, literally speaking, the snowball created by the first offer might not be sufficient to unleash a full-scale avalanche. While the outsider-owned exchange cannot distinguish between users with a high and a low value of θ, it has to overcome the informational problems by its offer structure. We do not want to go into more detail, but generally one can expect that the average offer of the outsider-owned stock exchange $E[a_\theta]$ will be higher than the offer depicted in equation (B.3). The outsider-owned exchange hence has an informational disadvantage vis-à-vis the users it wants to lure to its platform, which makes the transaction more costly.

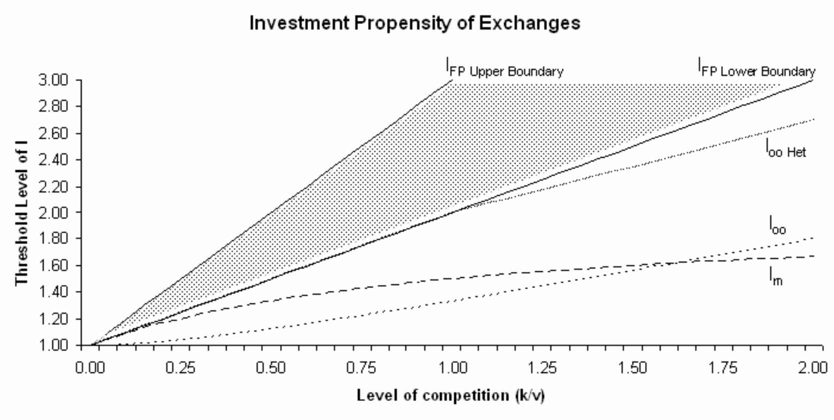

Figure 4.3: Thresholds for Different Governance Structures and Competition Levels

as it has a positive net present value, i.e. if the right hand side of inequality (4.1) holds. This is depicted by the line $I_{FPLowerBoundary}$. However, since, in equilibrium, the outsider-owned exchange attracts the transferable volume of all members, it can at least partly appropriate the surplus generated by this volume. In the extreme, i.e. if it acquires the whole rent, it reaches an upper boundary of investment costs $I_{FPUpperBoundary}$.

The graph I_m (dashed line) illustrates the case, where a mutual faces competition from another mutual entity. We see that the investment propensity rises quickly with the degree of competition, but levels off somewhat for higher k-to-v-ratios.

In contrast, a mutual exchange that competes against an outsider-owned exchange, denoted as I_{oo} (dotted line), initially has a lower investment propensity, but surpasses I_m for very high degrees of competition, i.e. for $k/v > 1.6$.

For mutuals that have heterogeneous members, with a majority possessing $\theta_h = 1.5 \times \theta$, the investment propensity will be as strong as at an outsider-owned exchange for low levels of competition (fine dotted line denoted as I_{ooHet}). The reason is the above mentioned second-sourcing effect in connection with the fact that part of the investment costs will be shared with those members that have no positive impact from the investment. For high levels of competition and high investment amounts, however, the costs of investing at the mutual exchange outweigh the second-sourcing effect and make an investment by the mutual unattractive. Consequently, the investment propensity will increase by a smaller pace than at the outsider-owned exchange.

Finally, if the majority of the members of the mutual exchange possess $\theta = 0$, i.e. they have no positive value from the investment, the exchange will not invest at all, which would correspond to a horizontal line at $I = 1$ in the figure.

4.2.3 The dynamic model - Viability of organizational forms

The framework we used in the last sections was a one-shot game, which is useful to analyze investment incentives in case of competition between different organizational forms. In the following, we want to focus on dynamic competition effects in order to analyze the viability of the respective governance regimes, in particular that of mutuals.[25] We will demonstrate that under certain conditions, an incumbent mutual exchange cannot survive, if an outsider-owned exchange enters its market. We will also see that an incumbent outsider-owned exchange will survive against another outsider-owned exchange on the other hand. These results imply that mutual exchanges that face competition from outsider-owned exchanges can only survive by changing their organizational form. Thus, our model provides a theoretical intuition for the ongoing demutualization wave in the stock exchange industry.

To model this, we consider an overlapping generations framework with discrete time periods and an infinite time horizon, i.e. $t = 0, 1, 2, \ldots, n$. Users of an exchange live for two periods in which they want to trade and in each period a new generation with a large number of users is born. To simplify the exposition, we assume that each generation has a mass of 1. Thus, at each period a "new" and an "old" generation exists, implying a continuum of agents of mass 2 at each date.

We denote the trading volume generated by the old generation at a certain time period as v and normalize it to $v = 1$, whereas the new generation generates a volume of $k = 1$ at the same date. Because of the long time periods we have in mind, we additionally assume a discount factor per time period of $\delta < 1$. Hence, in essence we are analyzing a particular case of our basic setup in terms of volume. The young generation decides freely where to allocate its trading volume k, while the old generation, for reasons to be explained in the next paragraph, always sticks with its volume at the exchange it decided to go one period earlier, i.e. when it constituted the young generation.

At each time period $t-1$, an identical investment opportunity with costs I arises for the stock exchange and generates a gross surplus of θ for its users at date t. The investment is, again in accordance with our basic setup, only beneficial if the young *and* the old generation participate. Using the notation of the last section, the investment condition in discounted value terms is

$$I < \delta(v + k)\theta \qquad \text{with } v, k = 1. \tag{4.17}$$

In the following we analyze two organizational forms: (1) An outsider-owned exchange that can charge an unconstrained trading fee of a_t^{oo} to its users in t to finance the investment that was initiated in $t-1$. (2) A mutual exchange that charges no entry fees and has no redemption rights makes its members pay the same amount a_t^m in case of investment irrespective of the generation they belong to.[26] In addition, with the young and old generation members being potentially heterogeneous groups, we have to specify the generation that has the control rights in the mutual exchange. In an overlapping generations framework, a generation born in $t-1$, but being in charge of the investment decision at date t, will have no incentive to invest into a new investment project at date t. This is due to the fact that the payoffs of this investment accrue at date $t+1$, where this generation will not exist anymore. Since we consider a mutual

[25] In this section we borrow heavily from Rey and Tirole (2001).

[26] Hence, here we are considering a nondiscriminatory mutual in its purest form which is not allowed to use entry fees, seniority-based charges, or redemption rights for members or transferable property rights. Of course, this is not a realistic assumption. However, because of their governance structure mutuals typically do not have the same high discriminatory power as outsider-owned firms. Thus, just to clarify the argument, the analysis in this section should be understood as modeling these differences in its extreme form. In a future version of the paper, we want to conduct a more balanced analysis by analyzing mutuals with some discriminatory power.

without redemption rights, there is no means by which they could benefit from the investment. Hence, to prevent a negative bias in the analysis against the mutual exchange, we presume that the investment decision rights will always be allocated to the young members.[27]

Investment behavior without competition Let us shortly discuss what happens in this framework if there is no competition between exchanges. An outsider-owned exchange would set a trading fee of

$$a_t^{oo} = \theta$$

in each period.[28] In this way, it extracts all the rents resulting from the investment project. Accordingly, the intertemporal profit of the outsider-owned exchange can be described as

$$\Pi^{oo} = \frac{\delta(v+k)\theta - I}{1-\delta}. \tag{4.18}$$

When comparing the profit function with investment condition (4.17), it is obvious that the investment will be undertaken as $\Pi^{oo} > 0$.

In contrast, a mutual exchange without discriminatory trading fees will have problems to get the investment process started. In fact, the first generation of members has to finance two consecutive investment projects at date 0 and date 1 via its trading fees, but only obtains returns from the first investment, which pays off at date 1. In this sense, the members of the second generation are free-riding on the first generation, since the mutual exchange is not allowed to charge different trading fees to users at a certain point of time. Let us consider this more formally. Given the investment process gets started, in the steady state, the trading fees at each date would be

$$(v+k)a_t^m = I \qquad \text{for } t > 0. \tag{4.19}$$

This will result in a net surplus V^m for each generation of members that is born *after* date 0, which amounts to

$$V_t^m = \theta_t + \delta\theta_{t+1} - \frac{I_t}{2} - \delta\frac{I_{t+1}}{2} = (1+\delta)(\theta - \frac{I}{2}) \qquad \text{for } t > 0 \tag{4.20}$$

since $\theta_t = \theta_{t+1} \equiv \theta$ and $I_t = I_{t+1} \equiv I$. To understand equation (4.20), note the following: At period t, a member of the new generation that is born in this period has to share the investment costs I_t with the old generation and enjoys the gross surplus θ_t stemming from the investment at date $t-1$. It also has to take into account that it will have to finance the investment costs of the next project at date $t+1$ with its trading fees in that period, which will be shared with the new generation, but also will enjoy the surplus θ_{t+1} from the investment project of date $t+1$ initiated at date t. Therefore, both components have to be discounted by the factor δ. Given our assumption on the investment project (4.17), this surplus is positive. Table 1 illustrates the overlapping generations (OLG) structure for an ongoing mutual exchange with $\theta_t(I_{t-1})$ denoting the surplus of an $t-1$-investment at date t.

However, to analyze whether a mutual exchange invests in the first place, one has to consider

[27]To align such a decision process with the majority rule, we only have to assume that the population of young users grows by a constant rate of $\eta > 0$ from period to period. For notational convenience we skip this issue here.

[28]To simplify the exposition in this section, we define the trading fee here in relation to the surplus generated by the investment. Hence, the trading fees are the *net* surcharges which users of the exchange have to incur as a result of the investment.

$t = 1, 2, \ldots$	t	$t+1$	$t+2$	$t+3$
Generation t	$\theta_t(I_{t-1}), \frac{I_t}{2}$	$\theta_{t+1}(I_t), \frac{I_{t+1}}{2}$		
Generation t+1		$\theta_{t+1}(I_t), \frac{I_{t+1}}{2}$	$\theta_{t+2}(I_{t+1}), \frac{I_{t+2}}{2}$	
Generation t+2			$\theta_{t+2}(I_{t+1}), \frac{I_{t+2}}{2}$	$\theta_{t+3}(I_{t+2}), \frac{I_{t+3}}{2}$

Table 4.1: The OLG Structure

that the first investment project will only get started if

$$V_0^m = \delta\theta - a_0^m - a_1^m = \delta(\theta - \frac{I}{2}) - I > 0, \tag{4.21}$$

which describes the fact that the first generation has to bear the investment costs of the first project at $t = 0$ alone, and share the costs of the second project at $t = 1$, from which it will not even benefit. Hence, the surplus from the investment project, θ, must be relatively high in order to get the investment project started. Inserting $v, k = 1$ and comparing (4.21) with (4.18), one can easily see that projects with a smaller surplus will be started only by an outsider-owned exchange. The reason for this is that a mutual exchange invests, if the surplus is higher than $\theta = \frac{I}{2} + \frac{I}{\delta}$, whereas the outsider-owned exchange already invests for a surplus higher than $\theta = \frac{I}{2}$. We conclude that even if a mutual exchange does not face competition by other exchanges, it has a lower propensity than an outsider-owned exchange of investing into projects, as long as it is not allowed to charge new members for investments made in the past. In effect, we have a *time horizon* problem in the sense that socially desirable investments might not be undertaken. Therefore, the analysis so far leads to similar results as stated in proposition 1 and 2.

Competition between two mutuals Competition in this framework will, similarly to our basic setup, center on the decision where the young generation will allocate its volume. For the old generation it makes no sense to switch to a new-entrant exchange, which still has to invest. The payoffs of this investment will accrue at a time where the old generation does not exist anymore. In the following, we assume, as in most parts of section 4.2.2.1, that the users can coordinate themselves to take the offer, which fits best their *common* interest, i.e. we apply the Pareto-dominance criterion. First, we want to analyze the case, where an existing mutual exchange, which has invested in the past, faces the threat of entry by a rival mutual exchange. As can be seen from condition (4.20), the surplus for each young generation from trading at the incumbent mutual exchange is $(1 + \delta)(\theta - \frac{I}{2})$. A rival mutual exchange m' could at best make an offer according to equation (4.21) of $V_0^{m'} = \delta(\theta - \frac{I}{2}) - I$, which is clearly less. Hence, a rival mutual exchange cannot succeed in taking over the market from the incumbent, if it has not invested in the new project beforehand and, naturally, if the investment projects of the two rival exchanges are similarly efficient. This result indicates that it is difficult for a newcomer mutual exchange to compete against an incumbent exchange, if the newcomer does not possess a project that is far better.

Competition between a mutual and an outsider-owned exchange The second case we want to analyze is the competition between an incumbent mutual exchange and a newly created outsider-owned exchange. The outsider-owned exchange knows that the mutual exchange will break down if the former can convince the new generation of users to trade on its exchange. In that case, the members would not retain their volume at the mutual exchange, and since the old members cannot profit from a new investment, they would decide not to invest, accordingly. Hence, X_2 will be successful in acquiring the new generation, whenever its best possible offer is better than that of X_1. Thus, if the profit of setting up a new outsider-owned exchange is higher than the surplus the young generation receives when trading its volume at the incumbent mutual exchange, i.e.

$$\Pi^{oo} = \frac{\delta(v+k)\theta - I}{1-\delta} > (1+\delta)(\theta - \frac{I}{2}), \tag{4.22}$$

X_2 can make an offer a^{oo*} to the young generation such that its payoff from trading at X_2 is at least as high as $(1+\delta)(\theta - \frac{I}{2})$. The young generation will trade at X_2, thereby generating a profit of $\Pi^{oo} - a^{oo*}$ for the exchange. Inserting $v, k = 1$ and rearranging gives us the following condition

$$4\delta\theta + 2\theta(\delta^2 - 1) - I(1+\delta^2) > 0, \tag{4.23}$$

which must be satisfied to defeat the incumbent mutual exchange's offer. A closer look at this condition shows that this will be more likely for higher values of θ and δ, and lower investment costs I. Then the rents, which can be expropriated from the young users, are large enough to enable X_2 to take over the market. Using the same line of argument, it is obvious that an entrant organized as mutual cannot defeat an incumbent outsider-owned exchange. The outsider-owned exchange, maximizing the profits of its investors, always has the possibility to underbid the offer made by the mutual exchange. Thus, we can postulate that in competition with an investor-owned exchange the mutual exchange is fragile, even if it has an incumbency advantage.

Competition between two outsider-owned exchanges Finally, we analyze the case in which an incumbent outsider-owned exchange faces the competitive threat by another outsider-owned exchange. The incumbent stock exchange again benefits from the fact that it has already invested in the past period. This ensures the stability and viability of the exchange in future periods. However, the incumbent outsider-owned exchange is constrained in the level of fees it can charge to the new generation. The potential entrant could induce the young generation to join the organization, in fact forming a new for-profit exchange by its own. Such an exchange would secure its owners at least $-I + \delta\theta$, even if it is anticipated that both exchange will compete later on for the still unborn generation in a Bertrand-fashion. Hence, if the investment project is so valuable that $\delta\theta > I$, the incumbent outsider-owned exchange cannot extract all the rents from its users. The better the investment technology of the potential rival exchange, the lower will be the profits of the incumbent exchange. We believe that exactly such a market environment describes today's situation in the stock exchange industry quite well. The stock exchanges face strong competition by users which, due to technological developments, can threaten to, and actually do, form their own trading platforms.

Competition between a mutual and an outsider-owned exchange - revisited However, this competitive threat also has an interesting feedback-effect on the offer, which an entering outsider-owned stock exchange can make to the young generation of an incumbent mutual exchange. Anticipating that it will face strong competition of the type just described in later periods, the outsider-owned exchange can offer at best its surplus

$$\Pi^{oo} = \frac{\delta(v+k)\theta - \delta\theta}{1-\delta}, \tag{4.24}$$

which has to be higher than $(1+\delta)(\theta - \frac{I}{2})$ in order to acquire the young generation. Inserting and rearranging gives a new and stricter condition on the parameters of the investment project which have to be satisfied. Hence, the entering outsider-owned exchange will gain the young generation's volume only if:

$$\frac{\delta\theta}{2\theta - I} > \frac{1-\delta^2}{2}. \tag{4.25}$$

Therefore, the anticipation of competition in the future deters the outsider-owned exchange slightly from taking over the market from the mutual exchange. However, the comparative statics regarding the parameters of the investment project remain the same as stated above.

Heterogeneity of users Heterogeneity of users would presumably strengthen the effects we described in this section. As already discussed in section 4.2.2.2, the competitive edge of the outsider-owned exchange is fostered, while the stability of the mutual exchange suffers when the members are heterogenous and the members with a low θ are in the majority. Insofar, we can expect that the dynamics, which we were able to illustrate here, will be even more powerful in case of investment projects with heterogeneity. In line with our interpretation of such projects, we therefore should observe particularly investments into non-core activities in order to unravel the market dynamics we described. However, a formal analysis of the heterogeneous case will be conserved for a later version of the paper. Summarizing the discussion in this section leads to the following proposition:

Proposition 3 *Under the assumptions that each period provides an investment project, which is only profitable for the exchange's total per period business* $(v+k)$ *and which has a homogenous influence on users, we have the following results in an overlapping generations approach:*

1. *An incumbent mutual exchange cannot survive against an outsider-owned stock exchange when condition (4.25) holds.*

2. *In contrast, an incumbent outsider-owned exchange can never be defeated by a mutual exchange.*

3. *The threat of entry by other for-profit stock exchanges or trading platforms does not undermine the viability of an incumbent outsider-owned exchange. However, it limits the market power of the incumbent outsider-owned stock exchange and forces it to share some rents with the new users, thereby making the exchange less profitable.*

Considering these three cases together, a mutual exchange, facing competition from an outsider-owned exchange, can only survive if it demutualizes and becomes an outsider-owned entity itself.

4.3 Empirical evidence

4.3.1 Hypotheses

The main results of our theoretical model need to be tested empirically in order to verify their validity. In particular, we are interested whether exchanges are indeed more likely to demutualize when they are under competitive pressure and whether an outsider-owned governance structure increases the propensity to invest into related activities, which is the essence of our propositions derived in section 4.2. We will therefore focus on two hypotheses that can be tested by the data available to us. First, as in Ramos (2005), we test whether competitive pressure has an impact on the likelihood that exchanges demutualize. Thus our first hypothesis states:

H1: Competitive pressure will increase the likelihood of demutualization for exchanges.

Second, we want to verify our theoretical outcome that for-profit exchanges have a stronger tendency to invest into related business activities than mutual exchanges. Our findings in the model refer foremost to outsider-owned exchanges as the results are mainly driven by the fact that these exchanges can take investment decisions unconstrained of correlated business interests that their members have. Therefore, we state the following hypothesis on this subject:

H2: Outsider-owned exchanges are more likely to invest into post-trading, derivatives trading and IT-development activities than mutuals.

4.3.2 Methodology

As we will see in detail in section 4.3.3, we employ variables describing the related activities, the governance regimes, and the competitive environment of exchanges. We will employ Probit regressions to test our hypotheses, since the data structure of our dependent variables, i.e. the governance and related activities variables, are all of dichotomous nature. One way to approach this issue is to estimate the effects of competitive pressure on the likelihood of demutualization and the effects that demutualization and competitive pressure have on the likelihood of investing into related business activities in two separate univariate Probit regressions. However, this creates a potential endogeneity problem as demutualization itself is explained by the competition variables and thus cannot assumed to be exogenously given, when we consider the investment activities of exchanges in related activities. As a result, it is more prudent to employ a bivariate Probit model as was proposed by Greene (1998) and Greene (2000, p.849-852) and estimate the investment decision and demutualization equations simultaneously.[29]

As we consider three distinct related areas in which exchanges can invest, we will estimate three simultaneous equation pairs. The first pair of equations calculates Probit regressions on the likelihood that the exchange invests into post-trading activities (SETTLE) and that the exchange is demutualized (DEMUT), respectively. For the remaining two pairs of equation systems, we substitute the dependent variable of the first equation with DERIV and SOFT in order to estimate the likelihood of an exchange being active in the derivatives and IT-services

[29] One drawback of this approach is that we cannot take into consideration our panel data structure as such a model is not provided by Stata 8. To alleviate this problem, we will adjust for within-cluster correlation of exchanges by using the cluster option. Additionally, we will separately estimate univariate random effects Probit regressions for robustness check purposes, as is outlined in Greene (2000, p.837-842) The results are provided in appendix B.5.

business, respectively. Therefore, the three regressions have the following form:

$$\begin{aligned}
SETTLE &= \vec{\beta_1}'\vec{x_1} + \epsilon_1, \quad SETTLE = 1\; if\; SETTLE > 0,\; 0\; else \\
DEMUT &= \vec{\beta_2}'\vec{x_2} + \epsilon_2, \quad DEMUT = 1\; if\; DEMUT > 0,\; 0\; else
\end{aligned} \tag{4.26}$$

$$\begin{aligned}
DERIV &= \vec{\beta_1}'\vec{x_1} + \epsilon_1, \quad DERIV = 1\; if\; DERIV > 0,\; 0\; else \\
DEMUT &= \vec{\beta_2}'\vec{x_2} + \epsilon_2, \quad DEMUT = 1\; if\; DEMUT > 0,\; 0\; else
\end{aligned} \tag{4.27}$$

$$\begin{aligned}
SOFT &= \vec{\beta_1}'\vec{x_1} + \epsilon_1, \quad SOFT = 1\; if\; SOFT > 0,\; 0\; else \\
DEMUT &= \vec{\beta_2}'\vec{x_2} + \epsilon_2, \quad DEMUT = 1\; if\; DEMUT > 0,\; 0\; else
\end{aligned} \tag{4.28}$$

$$\begin{aligned}
E[\epsilon_1] &= E[\epsilon_2] = 0,\; respectively \\
Var[\epsilon_1] &= Var[\epsilon_2] = 1,\; respectively \\
Cov[\epsilon_1, \epsilon_2] &= \rho,\; respectively
\end{aligned}$$

The maximum likelihood estimation is derived from the following equations with respective bivariate cumulative normal distributions Φ:

$$Pr[SETTLE = 1, DEMUT = 1|\vec{x_1}, \vec{x_2}] = \Phi(\vec{\beta_1}'\vec{x_1}, \vec{\beta_2}'\vec{x_2}, \rho) \tag{4.29}$$

$$Pr[DERIV = 1, DEMUT = 1|\vec{x_1}, \vec{x_2}] = \Phi(\vec{\beta_1}'\vec{x_1}, \vec{\beta_2}'\vec{x_2}, \rho) \tag{4.30}$$

$$Pr[SOFT = 1, DEMUT = 1|\vec{x_1}, \vec{x_2}] = \Phi(\vec{\beta_1}'\vec{x_1}, \vec{\beta_2}'\vec{x_2}, \rho) \tag{4.31}$$

Hence, the bivariate Probit model allows us to estimate the two equations simultaneously. In the spirit of the seemingly unrelated regression models, the disturbances may correlate and will be displayed by the parameter ρ.[30]

4.3.3 Data description

In equations (4.26) - (4.31) , vectors $\vec{x_1}$ and $\vec{x_2}$ are a (sub)set of independent variables with accompanying coefficients $\vec{\beta_1}$ and $\vec{\beta_2}$. To capture governance and competition, we employ the variables depicted in table 4.2. The first column provides the names of the employed variables, while the second column offers a brief description. The third column specifies in which form these variables are used in our regressions. Consider for example SETTLE, which is one of two dependent variables in our first simultaneous equations pair. For our independent variables, BOARDCOMP, for instance, is included in both $\vec{x_1}$ and $\vec{x_2}$, whereas LISTED, indicating exchanges with outsider-ownership, is only part of vector $\vec{x_1}$. As the purpose of the second equation and vector $\vec{x_2}$ is to estimate the determinants that affect the likelihood of demutualization, it makes no sense to include a state of governance that cannot exist *prior* to the restructuring. Columns four and five provide the mean and standard deviation of our variables, respectively.

In the following, we will describe the variables that we hand-collected for that purpose

[30] In a univariate Probit model, in contrast, the implicit assumption is that $\rho = 0$.

Variable	Description	in Regression	Mean	SD
$SETTLE_{i,t}$	Dummy for exchange i possessing post-trading in t	Dep. Variable	0.438	0.50
$DERIV_{i,t}$	Dummy for exchange i possessing derivatives trading in t	Dep. Variable	0.623	0.49
$SOFT_{i,t}$	Dummy for exchange i possessing software sales in t	Dep. Variable	0.200	0.40
$DEMUT_{i,t}$	Dummy for exchange i if demutualized in t	Dep. Variable	0.508	0.50
$LISTED_{i,t}$	Dummy for exchange i if publicly listed in t	$\vec{x}_1$	0.254	0.44
$BOARDCOMP_{i,t}$	Composition of board of directors of exchange i in t calculated as representation of different stakeholder groups by directors (sum of squared fractions of broker, issuer, investor, state and other representatives)	$\vec{x}_1$,$\vec{x}_2$	0.565	0.22
$\Delta TRADEREV_{i,t}$	Change in revenues per traded share from Cash market operations of exchange i from t to t+1	$\vec{x}_1$,$\vec{x}_2$	-0.08	0.37
$CMCONTROL_{i,t}$	Index for openness of capital markets provided Fraser Institute in home country of exchange i in t	$\vec{x}_1$,$\vec{x}_2$	7.293	1.89
$TRADECOST_{i,t}$	Elkins/McSherry trading costs (commissions and fees only) in home country of exchange i in t	$\vec{x}_1$,$\vec{x}_2$	33.27	16.3
$SIZE_{i,t}$	Log value of equity shares traded (PPP-adjusted) at exchange i in t	$\vec{x}_1$,$\vec{x}_2$	12.36	1.99

Table 4.2: Data Description

in more detail. While some of our variables are straightforward, the employed variables to capture the notion of competitive pressure require a lengthier discussion as it is rather fuzzy in its specification.

We acquired annual descriptive data on 50 stock exchanges, which are considered to be the main equity trading entities in the world according to the World Federation of Exchanges (FIBV), from the HP Handbook of World Stock, Derivatives & Commodity Exchanges 1999-2004 and the annual trading statistics reports of the FIBV. Additionally, we gathered information from stock exchange annual reports, web sites and by direct mail correspondence with exchanges.

We collected country-specific data from three sources: (1) Information on trading costs for 42 countries, which we were able to collect from the *Institutional Investor* that provided the figures calculated by Elkins/McSherry.[31] (2) To capture the economic openness of a country's capital markets, we used the 'Capital Market Controls' measure of the Fraser Institute compiled by Gwartney and Lawson (2005). (3) We used exchange rate and purchasing power parity data from the World Bank 'World Development Indicators' for currency conversion purposes.

Depending on the data requirements of our respective empirical analyses, we either considered the full sample of countries or only a subsample of it. The full sample was used to provide the descriptive 'event-studies' presented in section 4.1 and discussed in more detail in appendix B.6. Our regression analysis on the other hand demanded a richer data set, which reduced the sample size to 26 exchanges. The period under consideration is from 1999 until 2003, although for one variable (ΔTRADEREV) we also considered the change in data from 2003 to 2004.

To test the hypotheses advanced in section 4.3.1 empirically, we need variables that (1) capture different governance regimes, (2) related business areas that stock exchanges could potentially invest in, and (3) the notion of competitive pressure. In the following, we will discuss these variables in more detail.

[31]We obtained the data for the years 1996-1999 and 2001-2004. For the year 2000, unfortunately we were not able to get the data and therefore had to interpolate them.

Related business activities We will employ variables capturing related business activities for hypothesis H2. To that end, we identified the provision of derivatives trading, post-trading services and IT services as the main activities that are related to the traditional cash market operations of stock exchanges. We assigned the following dummy variables: (1) If an exchange reported derivatives trading volume to the FIBV and/or reported revenues from this activity in its annual reports and/or stated a majority stake in a derivatives platform in its annual reports, we assigned $DERIV$=1, and $DERIV$=0 otherwise. (2) An exchange was assumed to provide post-trading services, if it either reported these revenues separately and/or stated a majority stake in a settlement institution in its annual reports. We then assigned $SETTLE$=1, and $SETTLE$=0 otherwise. (3) Finally, exchanges that reported revenues from IT-service activities were assigned $SOFT$=1, and $SOFT$=0 otherwise.

Governance regime We need governance variables for both stated hypotheses. For hypothesis H1, we need a dependent variable that indicates whether an exchange has converted towards a demutualized entity. For hypothesis H2, we will employ a governance variable as independent explanatory variable, capturing outsider ownership in the exchange.

We distinguish between the following three different governance regimes: We define an exchange as (1) mutual, if the entity has not announced demutualization and operates on a one-member, one-vote basis or is controlled by the state. An exchange is considered as (2) demutualized, if the exchange announced demutualization, but has not sought a public listing yet. And an exchange is considered to possess a (3) demutualized, outsider-dominated structure, if it is publicly listed.

To operationalize the distinctions, we define two dummy variables. The variables can take the following configurations: (1) A mutual exchange, denoted as $DEMUT = 0 \wedge LISTED = 0$, i.e. neither demutualized nor listed. (2) A demutualized exchange, denoted as $DEMUT = 1 \wedge LISTED = 0$, i.e. demutualized but not listed. (3) A publicly listed exchange, denoted as $DEMUT = 1 \wedge LISTED = 1$, i.e. both demutualized and listed.[32]

Competition In our regressions, we are interested whether competition affects the behavior of exchanges to demutualize (Hypothesis H1). Additionally, when we estimate the impact of outsider ownership on investment decisions at stock exchanges, our regression models will also employ competition variables as control variables (Hypothesis H2).

Specifying competition in the stock exchange industry is relatively straightforward in theory and there is a significant body of literature that devoted to different aspects of competition in this area.[33] However, most empirical attempts to measure competition focus on one or few exchanges and normally use bid-ask spread information.[34] Large-scale international comparisons on the level of competition at stock exchanges are much rarer due to the demanding data requirements.

Alternative methods used by industrial economists to quantify competition seem to be difficult to implement in this industry. Take for example the widely used Herfindahl-index, which infers information on the competitive environment by calculating a concentration measure within an industry. Such an approach is not directly applicable here for at least two reasons: (1) On a country level, the number of sizable competitors is limited. In many countries the exchange industry has already consolidated, resulting in one major national stock exchange that serves

[32] Note that the configuration $DEMUT = 0 \wedge LISTED = 1$ does not exist, since all listed exchanges underwent a demutualization process before.

[33] Ramos (2003) provides a comprehensive survey on the literature concerned with competition in the stock exchange industry.

[34] Several examples are provided in the survey of Ramos (2003).

the lion's share of transactions.[35] A noticeable domestic threat to the incumbent exchanges may arise from alternative electronic trading venues and from large financial institutions that match customer buy and sell orders internally. Thus, if we had data on these trading volumes, such a concentration measure would be meaningful. However, to our knowledge, there is no database that is both consistent and comprehensive enough to meet our cross-sectional and longitudinal requirements. (2) Instead of measuring concentration within a national market, one could create supranational regions or even one 'world region'. However, besides the fact that the selection of regions would be highly subjective due to the lack of a clear distinguishing criterion, such an approach would also ignore the still persisting regulatory constraints for effective cross-country competition and home bias in equities trading.[36] Hence, it would be misleading to assume that stock exchanges are competing directly against each other on a (global) level playing field, as such a setting would strongly depend on the openness of the financial market to potential competitors. By the same token, we believe that for most countries in our sample, competitive pressure is more likely to be exerted by other domestic players, be they competing regional exchanges, electronic trading platforms or the exchanges' own customers. Therefore, a concentration measure on the national level would be more desirable in principle.

A further method is the use of the H-statistics by Panzar and Rosse (1987) in order to derive revenue elasticities for each exchange, providing a crude indicator whether the considered entity operates under perfect competition, monopolistic competition, or no competition. The method has great appeal insofar as it seeks to measure the impact of competition directly at the exchange. Andersen (2003) uses this approach and provides a measure for exchange-specific level of competition. One drawback is that the method demands a comprehensive breakdown of the cost and revenues, which we do not possess for all exchanges in our sample. Furthermore, it assumes that the firm objective is to maximize its profits, a condition that cannot be maintained for the mutual exchanges in our sample.

Another, more general point of concern when measuring competitive pressure is that exchanges are engaged in several activities that can experience different degrees of competitive pressure. For our purposes, it makes sense to focus on competition in the cash market operations for at least two reasons: (1) Cash operations represent the set of activity, which is provided by every stock exchange in our sample, whereas other - related - activities are only offered by some of them. Thus, in order to ensure comparability of our competition variables, we should concede ourselves to this activity. (2) Cash trading is what stock exchanges have been created for, initially. Thus, if we believe that competitive pressure had an impact on the decision of some stock exchanges to restructure their governance regime, we would conclude that the main driver for such a move should be strongly correlated with an exchanges' perception of how threatened this core activity is. In any case, even when we merely focus on the cash market operations, we are confronted with several distinct activities such as issuer services, trading services, the dissemination of market information and regulatory functions that may all be influenced differently by the underlying economical characteristics and the regulatory framework of the industry. Although the competitive pressure felt in these activities may be correlated to some extent, it becomes clear that measuring competition in this industry is far from being one-dimensional. As a result, we seek to shed light to this issue from multiple angles in order

[35] The exception represents the situation in the US, where Nasdaq and NYSE process both significant volumes in US equities. Also, in some countries such as Germany, regional exchanges still exist, but the trading volumes are insignificant compared to those of the main incumbent.

[36] In countries such as Italy, Spain and France, the national exchange still enjoys considerable regulatory protection by the so-called concentration rule, which serves as a barrier against entrants. However, with the implementation of a new regulatory framework for the European securities industry (MiFID) in 2007, the European Commission strives to create a more level playing field within the EU.

to achieve a comprehensive picture of the level of competition that an exchange experiences. In total, we will employ five competition variables in our regressions, which we discuss in the following:

(1) BOARDCOMP: One way to approach competitive pressure is to infer information from the relative bargaining power of different stakeholders of the exchange, particularly that of banks and brokers. The intuition is that - provided that exchanges were initially established by intermediaries - this group also had the control over the entity, which should be observable in their representation in the board of directors. Now, consider a situation where, due to more outside options for other stakeholder groups, such as issuers and investors, their bargaining power declines vis-à-vis these other groups. This may happen when new trading venues offer their services to issuers and investors. As a consequence, it seems likely that banks and brokers would be willing to grant a greater say to these customer groups by offering seats on the exchange's board. Thus an increased diversity of representation could be interpreted as a loss in bargaining power by the incumbent intermediaries, which should be the result of increased competitive pressure on the exchange and therefore could be the precursor to demutualization.

To this end, we assessed the board's degree of homogeneity. In a first step we distinguished between five stakeholder groups, namely intermediaries, issuers, investors, state and other, and counted the number of non-executive board directors that represent these groups. In a second step, we divided each groups' number of representatives by the total number of directors, squared the results and summed them up. As a result, our measure can reach a minimum value of 0.2 for a completely uniform distribution of representation among the five stakeholder groups and a maximum value of 1.0 for boards that are completely dominated by one group, which is usually the group of banks and brokers.[37] For our sample of 26 exchanges, we were able to calculate the variable in all years except for Euronext and Singapore in 1999. Here, we assumed a similar representation in the boards as in 2000, respectively. For our regressions, we ex ante assume that lower values of our measure will make a demutualization more likely. Thus, we expect a negative coefficient.

(2) ΔTRADEREV: This variable captures competition in a more direct way by focusing on the fees charged to its customers. Since the fee structure at exchanges is often very complicated and subject to negotiation with the customers, the official trading fees are neither very meaningful nor comparable across exchanges. We therefore approach this issue by calculating the revenues the exchanges earned *per traded share* to approximate their true fee structure. Acknowledging the fact that exchanges will differ in the way they report their revenues for cash trading activities and which components of trading services are included in these figures, we realize that the absolute level of revenues per traded share is not very useful. However, the *change* of revenues per traded share may have a stronger explanatory power for competitive pressure. The intuition is simple: Exchanges will tend to lower their prices (i.e. the revenues per share) only if they actually have to do so, which should often coincide with increased competitive pressure.[38] For our sample of 26 exchanges, we thus calculated the annual log-changes in revenues per traded share. From this measure, we ex ante expect a negative coefficient as this implies that a decrease in revenues led to a higher likelihood of demutualization.

[37] Our intuition remains largely unaffected for countries were the exchange was founded by the state. In our sample, the exchanges of Istanbul, Kuala Lumpur and Thailand were wholly owned by the state in 2003 and state representatives make up the majority of directors in the board. Thus, for these exchanges, our measure is close to one and therefore points in the same direction as if the board was only represented by intermediaries. Since a state-owned exchange is usually not under fierce competitive pressure, the inference on competition should be unaffected by this control structure.

[38] This line of reasoning may be less appealing in the case of not-for-profit mutuals, which may also lower prices to increase the welfare of their members.

(3) CMCONTROL: The economic openness of an exchange's home capital market could provide an indication on the contestability of the financial services industry in general and the stock exchange industry in particular. Thus, if a capital market is more open, then its incumbent should be under stronger competitive pressure than an exchange operating in a very repressive capital markets environment. To operationalize this notion, we used the index of 'Capital Market Controls' provided by Fraser Institute for the home capital markets in our sample, which assigns index values ranging from 1 (repressive) to 10 (completely open).[39] According to the metrics of this index, we would expect a positive coefficient, as this would mean that higher openness leads to higher competition, which in turn leads to higher likelihood of demutualization.

(4) TRADECOST: The trading fees and commissions that investors have to bear when they trade varies significantly across exchanges. We presume that this should be somewhat inversely related with the degree of competition that exchanges are exposed to. This is due to the fact that exchanges that operate in a more competitive environment will be forced to keep trading fees and commissions lower ceteris paribus than at trading venues, where competitive pressure is absent. To proxy this notion, we obtained data from the *Institutional Investor* which presented the trading costs incurred by institutional investors and calculated by Elkins/McSherry for the years 1998-2004.[40] The reports break the costs down into an explicit component, which include fees and commissions for brokerage and exchange services, and into a cost component that is more implicit in nature, namely market-impact costs. Since the latter depends strongly on the depths of the underlying market and to a lesser extent on the degree of competition in this industry, we decided to consider only the explicit cost components of trading.[41] We expect that lower trading costs are the result of competitive pressure and will lead to higher likelihood of demutualization. We therefore presume a negative coefficient.

(5) SIZE: It is well documented in the economic literature on network industries that larger firms will possess a stronger bargaining power vis-à-vis its customers and will tend to resist competitive pressure more easily than smaller exchanges.[42] We therefore want to include a proxy for the size of an exchange. As we are primarily interested in describing the competitive position of the exchange in its traditional cash market, we opted for the log values of annual trading volume in equity shares at an exchanges in US dollars.[43] We expect this variable to possess a negative relation to the likelihood of changing the governance regime.

4.3.4 Empirical Results

Table 4.3 displays the results from the bivariate Probit regressions for n=130 observations, where the upper panel displays the results from our maximum likelihood estimates for the first equation (SETTLE, DERIV, SOFT) and the lower panel shows the estimates from the second

[39] We used the data from column '4E' of the Economic Freedom of the World 2005 Annual Report data base for the years 2000-2003. For the year 1999 in our sample, we employed the data from 1995 as this was the closest year in which this data was provided prior to 2000.

[40] By using this type of data we implicitly presume that the trading costs measured per country are equal to the costs for the respective national exchange, we included in our sample, which may not be completely the case for countries possessing additional (regional) exchanges.

[41] Otherwise, exchanges with are larger liquidity pool could be potentially favored in our analysis vis-à-vis smaller exchanges merely on the grounds of possessing a deeper market. When comparing the portion of market impact costs as of total cost in the Elkins-McSherry data base for the top and bottom quartile of exchanges measured by value of shares traded in 2004, we however did not find large differences. They amount to 36% and 33%, respectively. As expected, incorporating market impact costs into our analysis therefore has no significant effect on our results.

[42] For economics of network industries see for example Economides (1996)

[43] We adjusted the figures by the purchasing power parity obtained from the data bases of the World Bank (World Development Indicators 1998-2004)

equation (DEMUT), respectively. The respective Wald-χ^2-value for each of the three regressions in columns (2), (3) and (4) is large, signifying that the hypothesis that our estimated coefficients are zero can be rejected. The correlation term ρ suggests that the correlation for our SOFT-regression in column (3) seems to deviate substantially from zero. Furthermore, the Wald-test of ρ=0 provides weakly significant support on the 15%-level that the term is significantly different from zero. As a result, a separate estimation of the DEMUT and SOFT-regression should be treated with caution.[44]

	Bivariate Probit Regressions		
(1) **Related Business Activity:**	(2) **SETTLE**	(3) **DERIV**	(4) **SOFTWARE**
LISTED	**1.053****	**0.749***	**1.372****
Std. Err.	*0.462*	*0.397*	*0.603*
BOARDCOMP	**0.148**	**0.677**	**0.118**
Std. Err.	*0.843*	*0.936*	*0.998*
ΔTRADEREV	**0.417**	**-0.032**	**-0.469***
Std. Err.	*0.370*	*0.297*	*0.265*
CMCONTROL	**-0.283****	**-0.02**	**0.179**
Std. Err.	*0.126*	*0.136*	*0.219*
TRADECOST	**0.006**	**-0.056*****	**-0.035†**
Std. Err.	*0.012*	*0.014*	*0.022*
SIZE	**0.019**	**-0.377****	**0.006**
Std. Err.	0.102	0.162	0.123
CONST	**1.115**	**6.503*****	**-2.058**
Std. Err.	*1.919*	*2.406*	*2.809*
Demutualization:			
BOARDCOMP	**-2.681*****	**-2.554*****	**-2.684*****
Std. Err.	*0.940*	*0.897*	*0.957*
ΔTRADEREV	**-0.209**	**-0.188**	**-0.202**
Std. Err.	*0.439*	*0.443*	*0.433*
CMCONTROL	**0.298*****	**0.301*****	**0.301*****
Std. Err.	*0.115*	*0.114*	*0.113*
TRADECOST	**-0.024***	**-0.023***	**-0.023***
Std. Err.	*0.014*	*0.012*	*0.013*
SIZE	**-0.270*****	**-0.266*****	**-0.263*****
Std. Err.	*0.094*	*0.097*	*0.092*
CONST	**3.454***	**3.282***	**3.295***
Std. Err.	*1.833*	*1.783*	*1.769*
Observations	130	130	130
Wald $-\ \chi^2$	60.64	74.42	43.03
ρ	0.305	0.154	0.369
Wald test of $\rho = 0$: χ^2/**Prob** $> \chi^2$	1.650/0.199	0.357/0.549	2.315/0.128

†, *, **, *, represent 15%, 10%, 5% and 1% levels, respectively.**

Table 4.3: Bivariate Probit Regressions Results

Results for hypothesis H1 Hypothesis H1 stated that increased competitive pressure will increase the likelihood of demutualization. As can be seen in table 4.3, demutualization is significantly influenced by all of our competition variables, save for the ΔTRADEREV-variable.[45]

The results virtually do not vary across our three regressions in columns (2), (3) and (4). As expected, a less homogeneous board composition, i.e. when BOARDCOMP becomes smaller, significantly increases the likelihood of demutualization, which supports the notion that exchanges being under stronger competitive pressure (here expressed in terms of their bargaining power vis-à-vis other stakeholder groups) were more likely to demutualize. A similar picture provides our CMCONTROL-variable, where we observe a significant increase in the propensity

[44] We provide the results from estimating the equations separately in appendix B.5 as a robustness check to our bivariate regressions. For that matter, we employed univariate Probit regressions with clustering and with random effects as well as a univariate Logit regression with random effects. However, we find no material changes in our estimates except for the DERIV-regressions, where the coefficients of the LISTED-variable is only significant in the Probit regression with clustering. Furthermore, the estimate of the DERIV-equation in the Logit random effects model does not bring useful results.

[45] However, at least the sign in all three regressions is as expected: A decrease in revenues per traded share led to a higher likelihood of demutualization.

to demutualize at exchanges that are based in countries with relatively open and thus more competitive capital markets. Our variable TRADECOST also significantly displays the expected negative sign, implying that lower trading costs for investors lead to a higher likelihood of demutualization. Finally, our SIZE-measure also produces the expected results, displaying a significantly negative relation between size of the exchange and its likelihood of demutualization.

In summary, our regressions strongly support our theoretically derived hypothesis H1 that competitive pressure influences the likelihood of demutualization.[46]

Results for hypothesis H2 Hypothesis H2 states that an outsider-owned governance structure will have a positive impact on the likelihood of investments into related activities.

Our results confirm hypothesis H2 for all three related business activities, as the coefficient of the LISTED-variable is significantly positive in each case. However, the relationship seems to be weaker in the DERIV-case, where we see significance only on the 10%-level.

The impact of outsider-ownership on the propensity of exchanges to invest into related activities is quite clear. Each of the regressions indicates that outsider-owned exchanges are more active in this field. Interestingly, this observation is not as clear for investments into derivatives trading. Furthermore, our robustness checks with univariate Probit regressions largely do not confirm a significantly positive impact of outsider-ownership on the likelihood of possessing a derivatives trading platform. Therefore, customer-owned mutuals might be equally likely to invest in this field. Using the line of argument of our model, we would argue that this may be due to the higher proximity of the derivatives business with the customers' own (cash-trading) business compared with the other two considered activities. As a consequence, the potential rents may distributed more evenly across different types of members in this related activity.

4.4 Conclusion

This paper presented a model that explains why exchanges have increasingly demutualized in recent years. This is due to the fact that mutual exchanges cannot effectively compete against other exchanges, especially against outsider-owned, for-profit trading platforms. However, we demonstrate that they can survive against competing exchanges when they demutualize. Furthermore, our model explains the ongoing trend of diversification among stock exchanges and shows that outsider-owned exchanges will have a higher propensity to do so vis-à-vis mutual exchanges. Our main results are empirically confirmed by a five year sample of 26 stock exchanges. In particular, we find evidence that competitive pressure induces exchanges to demutualize and that publicly listed exchanges are more likely to invest into related business activities.

[46]Our results are confirmed by the finding of Ramos (2005) who comes to similar conclusions in her univariate Probit regressions.

Chapter 5

Stock Exchange Business Models and Their Operative Performance*

*This paper has been accepted for publication in the *Journal of Banking and Finance*. I thank the participants of the conference ”Future of Clearing and Settlement Systems: Europe and Beyond” at Cass Business School, London and the two anonymous referees for valuable comments. I am indebted to Reinhard H. Schmidt, Peter Gomber, Alistair Milne, Roland Rott, Heiko Schmiedel, Jens Tapking, Marcel Tyrell, Séverine Vandelanoite and Marco Weiss for fruitful discussions.

5.1 Introduction

In recent years, stock exchanges have increasingly diversified[1] their operations into related business areas such as derivatives trading, post-trading services and software sales. Considering the world's 50 largest stock exchanges according to the World Federation of Exchanges (FIBV), figure 5.1 displays the development in the number of exchanges that have provided related activities besides their traditional cash market operations.[2] The number of exchanges that added post-trading services to their business portfolio rose from 22 to 30, while the number of venues that operate a derivatives trading platform marked up from 25 to 31. Despite the strongest relative increase, providers of software solutions remained rather scarce, with three exchanges offering this service in 1999 and seven in 2003.

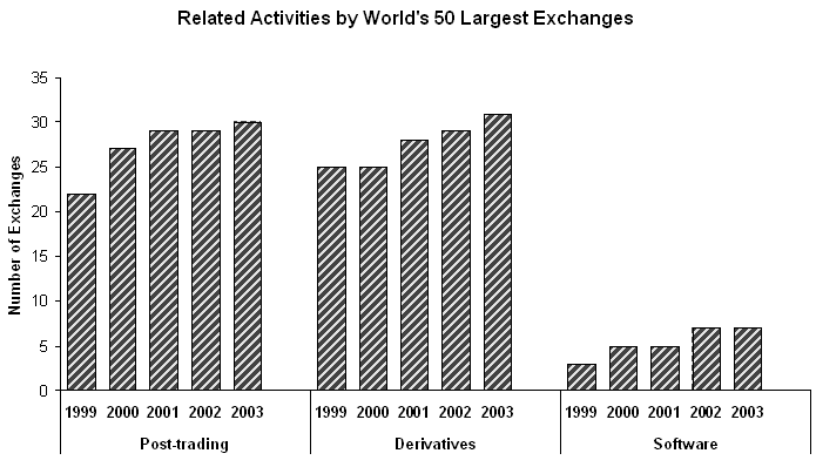

Figure 5.1: Related Activities by Exchanges 1999-2003

Integration activity and governance Interestingly, the great majority of exchanges that contributed to this rise were trading venues that have migrated from a mutual towards a shareholder-based, for-profit organizational form, a process, which is usually denoted as *demutualization*[3]. In fact, stock exchanges that diversified into post-trading or software sales activities were exclusively profit-oriented, while the same group accounted for half of the increase in derivatives trading during the considered time span.[4] There are at least two reasons why predominantly profit-oriented exchanges pursued the integration of related activities: First, these areas possessed a stronger growth potential than the traditional cash market, an aspect

[1] The terms ´integration´ and ´diversification´ are used as synonyms in this paper.

[2] We used the following scheme to decide whether an exchange has diversified: If an exchange reported derivatives trading volume to the FIBV and/or reported revenues from this activity and/or stated a majority stake in a derivatives platform in its annual reports, we considered the exchange to be horizontally integrated in derivatives trading. An exchange was assumed to provide post-trading services, i.e. clearing and/or settlement and/or custody services, if it either reported these revenues separately and/or stated a majority stake in a settlement institution in its annual reports. Finally, exchanges that reported revenues from IT-service activities separately were considered to be active in the software sales business.

[3] Aggarwal (2002) discusses the process of demutualization in detail.

[4] More precisely, the exchanges that added post-trading to their business during 1999 and 2003 were Hellenic Exchange, Copenhagen, Deutsche Börse, Italian Exchange, OMHEX, Vienna, National Stock Exchange India, and Philippine. Derivatives trading was introduced by Bermuda, Amex, Lima, Hellenic Exchanges, Istanbul, Johannesburg, and London Stock Exchange. One exchange, Toronto Stock Exchange, ceased to operate a derivatives platform. Therefore, the net increase in derivatives platforms is six. A software sales division was established by Singapore, Toronto and Tokyo.

which is particularly relevant for exchanges that strive for profit-maximization and relatively unimportant for non-profit entities such as mutual exchanges. Second, demutualized exchanges also have presumably more leeway to pursue attractive business opportunities due to a different control structure: Traditional mutual exchanges are usually owned and dominated by their customers[5], which not only seek to maximize the value of the trading venue, but also take into account their own business interest as customers of the exchange. Therefore, as they ultimately control the activities of the exchange, they can e.g. prevent investment decisions that threaten their own business interests, even though they would increase the value of the trading franchise.[6] In contrast, profit-oriented exchanges, particularly those that are publicly listed, are mostly dominated by outside owners, which merely have a financial interest in the entity.[7] Therefore, as the vested interests of customer-owners are replaced by the outside-owners' common goal of maximizing the value of their company, an exchange's management can more freely pursue value-enhancing projects such as diversifying into related business fields.

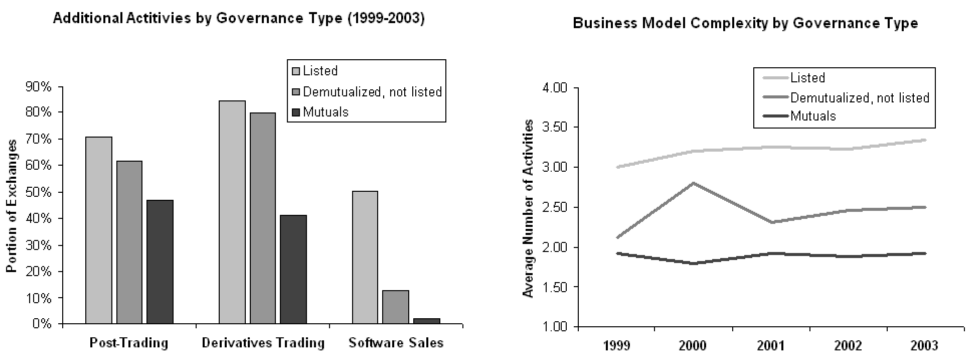

Figure 5.2: Related Activities by Governance Type 1999-2003

To demonstrate how integration activity varies among different governance structures, we present the two graphs in figure 5.2. The graph on the left side groups the exchanges according to their governance type (mutual, demutualized, publicly listed) and displays the five-year average portion that is diversified into the considered activities for each group. It can be seen that diversification into related activities is most pronounced for the group of publicly listed exchanges (light grey bars) as 71% of them provide post-trading services, 84% offer a derivatives trading platform and 50% are active in the field of software sales compared to only 47%, 41% and 2%, respectively, for the group of mutual exchanges (dark grey bars). The graph on the right side provides a slightly different perspective on the same issue. Here, the average number of activities provided by mutuals, demutualized and publicly listed exchanges are shown for the considered time period. Mutual exchanges have on average two business activities, i.e. one additional besides the traditional cash market operation, whereas listed exchanges are engaged on average in approximately three activities. Demutualized exchanges that are not listed lie in

[5]These are mainly banks and brokers that conduct their businesses on the exchange.

[6]A prominent example in this respect was the reluctance of some customer-owners to introduce an electronic trading platform due to fears that this could adversely affect their brokerage business. In an analogous manner, this could be observable for investments in related business activities. Confer Steil (2002) for an elaborate discussion on this matter.

[7]Nevertheless outsider ownership can also have the opposite effect on integration activity as a recent case at the Deutsche Börse demonstrates. Here, a public dispute between the management of the Deutsche Börse and one of its owners, a hedge fund called TCI, emerged over the economic merits of a merger with the London Stock Exchange and culminated in the withdrawal of the takeover offer. TCI named the overly expensive bid price as the main reason for their strict opposition against a merger.

between these extremes.

In order to assess the different degrees of importance of related activities for profit-oriented as opposed to non-profit stock exchanges, figure 5.3 displays the average revenue breakdowns of publicly listed and mutual entities for a sample of 28 exchanges during the years 1999 and 2003.[8] The revenues from derivatives trading, post-trading services and software sales were substantial for the listed exchanges, since they represented roughly half of their total operating revenues (left panel). For mutual exchanges, related activities played a subordinate role and the lion share of their revenues was generated on the traditional cash market (right panel).

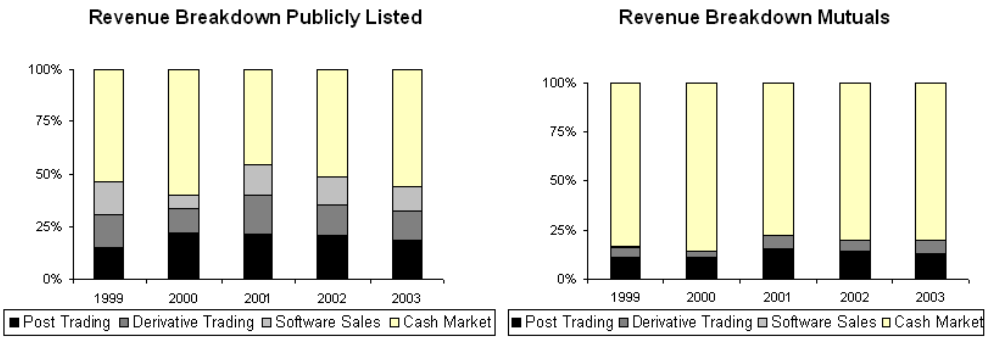

Figure 5.3: Average Revenue Breakdown of Mutual and Listed Exchanges in Sample

Integration activity and efficiency While diversification seems to be an attractive way to boost revenue and profit of an exchange, industry participants, politicians and academics point to the possibility that some business combinations could have detrimental effects on social welfare. They claim that particularly vertical integration, i.e. the combination of cash trading and post-trading activities, could lead to anti-competitive foreclosure strategies by (profit-oriented) exchanges resulting in higher entry barriers for potential competitors and therefore higher transaction fees.[9] However, there are also proponents of vertical integration claiming that the combination of trading and post-trading activities enables the exchanges to handle transactions faster, more safely and less costly by using straight-through-processing applications, which would ultimately result in lower prices for customers.[10] We believe that this discussion touches multiple - potentially intertwined - dimensions that need separate analysis beforehand in order to be able to assess the overall effects on welfare in a second step. In particular, we want to disentangle aspects of (1) *proper corporate governance regimes* from those that are related to (2) *efficient business models* in this industry.

(1) The governance regime of the entities is certainly a highly relevant aspect that needs to be analyzed from a social welfare perspective. Special attention should be devoted to the

[8]These exchanges are also used in the subsequent efficiency and factor productivity analysis and represent approximately 85% of the world's equity trading volume executed on exchanges. The sample will be presented in more detail in section 5.3.1. Note that the yearly average revenue breakdown does not comprise the same exchanges for the respective years, since some exchanges changed their governance. Hence, the average revenue breakdown of listed exchanges consists of two exchanges in 1999, whereas the 2003-figure includes the average of nine stock exchanges.

[9]For academic contributions discussing the merits of horizontal and vertical integration in the (European) securities transaction industry, see for example Milne (2002), Köppl and Monnet (2003), Tapking and Yang (2004), van Cayseele (2004), and Serifsoy and Weiss (2007).

[10]A strong advocate of vertical integration is the management of Deutsche Börse. In their view, not vertical integration but the different regulatory regimes in Europe prevent an effective competition among post-trading institutions. See for example Seifert (2003) and Deutsche Börse Group (2005).

impact of ownership structure and objective function of an exchange on the price and quality of its services. While outsider-owned, for-profit entities will seek to earn rents and therefore may charge prices that are above marginal costs, these rents may also induce the necessary incentives to invest in quality-enhancing technologies which may not exist if non-profit firms provide these services.[11]

(2) Irrespective of the governance regime, however, it needs to be clarified whether the combination of certain business activities makes sense from an operational efficiency perspective. Generally, integration of related business fields could lead to difficulties in managing the firm efficiently, since it adds to the complexity of existing business processes. However, certain business combinations may also enable the exchange's management to utilize inherent synergies between activities. An efficiency analysis that seeks to answer this question can be conducted in two different ways. The first approach, depicted on the left hand side of figure 5.4, would be to compare the relative efficiency of exchanges with differing degrees of diversification. If the results indicate that diversified exchanges (e.g. firms A, C or D) are more efficient and productive than cash market-only exchanges (i.e. firm B), then this would be a clear case to support the former business models from a social welfare perspective, provided that an optimal governance regime can be implemented. However, if diversified firms do not exhibit a higher operative efficiency than firms focusing on the cash market, then the reverse conclusion cannot be drawn from this method.[12] Instead, a second approach, as shown on the right hand side of figure 5.4, would be necessary that compares the efficiency of a diversified entity combining certain activities under one roof with the efficiency of multiple firms providing these activities separately. Hence, the efficiency of e.g. vertical integration would necessitate the comparison of an exchange that combines trading and post-trading activities (e.g. firm A) with a setting where these services are provided by three independent entities, namely an exchange, a clearing house and a settlement institution (e.g. firms B, C, and D). Evidence for the superiority of combined entities over separate entities would then lead to the conclusion that such an integration of activities is preferable, and vice versa.

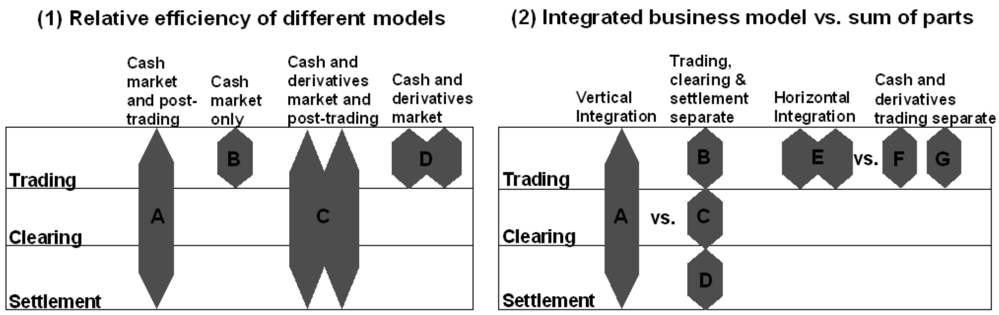

Figure 5.4: Two Efficiency Measurement Methods

Related literature To date, there exists only a small number of studies on how diversification may affect the operative performance of exchanges. We are aware of two contributions which analyze the performance of exchanges and take different business models into account. The author of both papers is Schmiedel. He analyzes stock exchange performance by employing

[11] A more detailed discussion on this issue can be found in Serifsoy and Weiss (2007).

[12] A diversified exchange may not be as efficient as a focused exchange, but it may still be superior to a situation where the same set of activities are provided by multiple, separate entities.

two frontier efficiency methods. While Schmiedel (2001) employs a parametric stochastic frontier model to evaluate the cost efficiency of European stock exchanges during 1985 and 1999, Schmiedel (2002) applies a non-parametric method for the 1993-1999 period.[13] In Schmiedel's first paper, which controls within the regression for exchanges that possess both derivatives trading and post-trading services, he finds a positive impact of integration on cost efficiency.[14] His second paper indicates that the mean of factor productivity gains, i.e. the annual change in technical efficiency, is higher for exchanges that focus on cash market operations.[15]

Contribution of the paper The primary focus of Schmiedel's papers is not to elaborate on differences in business models, but to apply the methodology on the stock exchange sector in general. Our paper is different insofar as it conducts an efficiency analysis that devotes particular attention to business models and analyzes the causes for differences in greater detail. Additionally, our sample is more recent (1999-2003). As in Schmiedel (2002), we will also employ a non-parametric approach to calculate relative efficiency scores, albeit using a broader set of output variables in order to better capture the various activities that stock exchanges are engaged in. Furthermore, in contrast to his proceeding, we will go a step further by regressing the derived estimations of efficiency and productivity on a set of factors mapping the framework in which the respective exchanges are embedded. This procedure will then highlight whether there is a significant impact of different business models on the performance of the stock exchanges.

This limits our analysis to the first approach outlined in figure 5.4. We consider this as a first step to gain insights whether a horizontal and/or vertical integration strategy promises efficiency gains compared to staying focused on cash market operations. Although some papers exist for the second method, such as from Pulley and Humphrey (1993) who measure scope economies of banks with different activities, we refrain from using a similar method in this paper, since we do not possess the appropriate data from entities that solely provide one of the related activities, i.e. independent derivatives exchanges, clearing houses, settlement providers or software companies.[16] Another drawback of their approach is that we would have to estimate a parametric production function in a very specific way in order to deal with the fact that some exchanges possess an output of zero for certain activities. As we will later also argue against the employment of stochastic frontier analysis, we prefer not to impose a certain structure on the production functions of exchanges, as we do not know how they look like in reality.

Hypotheses The purpose of this paper is therefore to determine whether stock exchanges that pursue certain integration strategies operate more efficiently. As will be explained in detail in section 5.2, we approximate the operative performance of exchanges by relative technical efficiency and factor productivity scores. Furthermore, as will be presented in section 5.3.2.2, we consider four integration strategies that can be compared to a cash market-only business model, allowing us to formulate the following four hypotheses:

[13] Both methodologies are widely accepted and were already used for efficiency measurement of financial institutions by a myriad of other papers. Berger and Humphrey (1997) provide an comprehensive survey on this topic.

[14] Confer Schmiedel (2001, p.22)

[15] Confer table 7, the 'Malmquist index'-column for "Equity only" and "Exchanges with derivatives" on page 26 of Schmiedel (2002).

[16] Pulley and Humphrey (1993) encounter a similar problem and are therefore only able to calculate an upper boundary of potential scope economies. In principle, such separate data is more easily available in the exchange industry than in the banking industry. However, the collection of such information and the use of their methodology would in fact create a new paper, which we leave for future research projects.

H1: Stock exchanges that diversify into derivatives trading possess a higher technical efficiency and factor productivity than cash market-only exchanges.

H2: Stock exchanges that diversify into post-trading services possess a higher technical efficiency and factor productivity than cash market-only exchanges.

H3: Stock exchanges that diversify into derivatives trading and post-trading services possess a higher technical efficiency and factor productivity than cash market-only exchanges.

H4: Stock exchanges that diversify into derivatives trading, post-trading services, and software development and sales activities possess a higher technical efficiency and factor productivity than cash market-only exchanges.

The papers is organized as follows. Section 5.2 describes the methodology used in our paper. Section 5.3 presents the employed data and our results. An interpretation as well as the robustness of our findings are also discussed here. Section 5.4 concludes.

5.2 Methodology

We first provide a brief overview of how to measure technical efficiency and total factor productivity via a non-parametric frontier approach called *Data Envelopment Analysis* in section 5.2.1. Section 5.2.2 describes how the specific effects of further factors such as different business setups are disentangled via regression analysis.

Before we proceed, it seems warranted to briefly discuss the need for a relatively sophisticated way to measure efficiency.[17] In principal, one could simply divide the main output of stock exchanges by an appropriate input measure, e.g. by using the ratio of trading volume processed to the total assets or number of staff employed by the exchange. While the ease of calculation is certainly appealing, we doubt its appropriateness for the stock exchange industry. The main reason for this - and which actually touches the heart of our paper - is that exchanges differ substantially in the set of activities they provide. Since the integration of related activities necessitates additional assets and staff, a simple trading volume/number of staff or trading volume/assets-ratio would distort the efficiency scores in favor of exchanges that focus on operating a cash market, whereas the additional outputs of more diversified exchanges would not be taken into account.

5.2.1 Data Envelopment Analysis and Malmquist-Productivity

Data Envelopment Analysis DEA was introduced by Charnes, Cooper, and Rhodes (1978). Using their linear programming algorithm enables the calculation of relative technical efficiency[18] values for similar entities, which process multiple inputs of resources into multiple outputs of products or services. Our analysis will focus on technical instead of economic efficiency, as it liberates the analysis from assuming a potentially ill-defined economic objective

[17] This legitimate objection was raised by one of the referees.

[18] The terms technical and economic efficiency were coined by Farrell (1957). In his definition, *technical efficiency* is achieved when an increase in any output requires a reduction in at least one other output or an increase in at least one other input and if a reduction in at least one input requires an increase in at least one other input or a reduction in at least one output. *Economic efficiency*, on the other hand, incorporates information on prices for the respective inputs and outputs and an economic objective to be pursued such as cost minimization or revenue maximization. It is achieved by implementing the cost minimizing or revenue maximizing production plan. Confer Fried, Lovell, and Schmidt (1993, p. 9-18)

function such as profit motivation. This is a more appropriate means to assess the relative performance between for-profit and not-for-profit entities from the same industry.[19]

The efficiency scores of each entity under evaluation, which we later denote as EFF, are determined by calculating the deviation each organization has from an efficient frontier. The frontier itself is set up as a piece-wise linear combination of best-practice observations spanning a convex production possibilities set. The computed efficiency value is thus a *relative* measure as it quantifies the performance of each entity in comparison to a set of "best"-performing peers. DEA is a non-parametric approach that has no predetermined functional relation between inputs and outputs, i.e. there are no a priori weights attached to these factors. Instead, the weighting of the factors that are involved in the production process is endogenously optimized for each decision making unit (DMU)[20] individually. By doing so, the weighting factors of the inputs and outputs, i.e. the underlying production technology, can vary substantially among the DMUs. This allows each DMU to attain the highest possible efficiency score subject to the constraint that the efficiency values of all remaining DMUs stay within the defined boundaries of the efficiency measure when using the same weighting scheme.[21] The resulting flexibility in the production function is an advantage whenever the true functional relationship between inputs and outputs is unknown. This is clearly the case in the stock exchange industry so that it seems sensible to allow for different types of production functions during the analysis. Considerable uncertainty also remains about the technological characteristics of this industry. As a consequence, we will calculate efficiency and factor productivity scores for both a constant returns-to-scale (CRS) as well as a variable returns-to-scale (VRS) environment.[22] A detailed description of the mechanics of Data Envelopment Analysis is provided in appendix C.1

A limitation of DEA is that it does not account for random error. Potential noise may evolve from inconsistencies in the input and output figures, diverging accounting practices and/or differing accounting standards or random events that either positively or adversely influence a DMU's performance. Furthermore, noise may not only shift the efficiency of the concerned DMU. It might also have an alternating influence on all other DMUs when the noise-affected DMU is a member of the efficient frontier. As a result, econometric methods such as Stochastic Frontier Analysis (SFA) are sometimes seen in a more favorable light among empirical researchers in order to assess the efficiency of firms.[23] But these parametric approaches have their own limitations. Wilson and Simar (1995) present several arguments why DEA is not dominated by these methods: Not only do parametric methods require an a priori specification of the used technology, they also need to predispose the noise and the inefficiency process. Thus, potential errors in the specification of the functional form may be mixed up with the DMU's inefficiency. Moreover, the incorporated noise term only allows for measurement error in the regressand, while bias and inconsistency may also exist in the explaining variables. They therefore conclude that "the presence of a noise term in the parametric models may represent only a slight advantage, if at all."[24] A more practical drawback of SFA is the difficulty to find appropriate input prices for stock exchanges.[25]

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[19]Confer for example Pestieau and Tulkens (1993, p.300-301).

[20]The term "DMU" was introduced by Charnes, Cooper, and Rhodes (1981) and has been widely adopted by other authors.

[21]This procedure ensures that a DMU's activity can be justified from an economic point of view as it assumes that the respective decision makers act according to certain factor prices and thus give appropriate weights to the employed inputs and produced outputs in line with the notion of striving for maximum efficiency.

[22]VRS allows for varying returns-to-scale characteristics for different levels of input-output combinations. Confer appendix C.1 for further details.

[23]Confer for example Schmidt (1985) who calls DEA "non-statistical". Yet, Banker (1993) provides a statistical underpinning for the methodology.

[24]Wilson and Simar (1995, p.3-4)

[25]While the price of labor may be reasonably approximated by the personnel expenses per employee, a

The Malmquist-productivity index The Malmquist productivity was introduced by Caves, Christensen, and Diewert (1982). While DEA measures the relative efficiency of a DMU for a certain year, the Malmquist-productivity index compares year-on-year *changes* in technical efficiency. The method bases on similar DEA-like linear programming techniques and gained additional appeal when Färe et al. refined it by decomposing the productivity change into two separate effects, namely the *change in efficiency* and *technological progress*. In the following, we sketch the fundamental issues of this method.[26]

Consider the left panel of figure 5.5 (CRS) where a DMU's one-input (x), one-output (y) constant returns-to-scale production process is depicted for two subsequent periods t and $t+1$ with corresponding efficient production frontiers T^t and T^{t+1}. Irrespective of the observed input-output-combinations (x^t, y^t) and (x^{t+1}, y^{t+1}) the slopes of the two best practice frontiers indicate whether *technological progress*, which we denote as $\Delta TECH$, has occurred from period t to $t+1$. As the slope of T^{t+1} is steeper than that of T^t, technology must have progressed, for it is possible in $t+1$ to produce the same amount of output with fewer inputs. This can be readily seen when focusing on points b and c in the figure which determine the inputs that are required to produce the same output level y^t in the respective periods. Thus, using technology T^{t+1} enables the same output to be converted by $(0b - 0c)$ fewer inputs. To see the *change in efficiency*, which we denote as ΔEFF, one needs to take a closer look at the actual input-output combinations, i.e. (x^t, y^t) and (x^{t+1}, y^{t+1}) of the decision making unit (DMU). Apparently, neither of the two is produced in an efficient manner. Note, that the points b and f represent the minimum input levels for the given output levels y^t and y^{t+1}. As the deviation from the frontier has increased in period $t+1$ compared to period t, there was a decline in efficiency for this DMU. In total, the two factors that comprise the overall productivity change of the DMU, i.e. $MQ = \Delta EFF \times \Delta TECH$, are running in opposite directions in our illustration. The right panel (VRS) depicts the case for variable returns-to-scale and can be analyzed analogously. Here, $T^t \subset T^{t+1}$ which again implies that technological progress must have occurred. In appendix C.2, we provide a more detailed description of the corresponding linear programs that need to be solved.

5.2.2 Regression analysis

Section 5.2.1 presented our approach to calculate DEA-efficiency and Malmquist-productivity values. We so far assumed to employ input and output variables into the calculation that are directly related to the operations of an exchange. Additional factors representing the framework in which the exchanges operate, such as differing business models, have so far not been included in our analysis. We will use a two-stage process that provides a linkage between these *operational* and *framework* factors. Stage one encompasses the aforementioned calculation of efficiency and productivity values and is based solely on operational inputs and outputs. In the second stage, the resulting efficiency and factor productivity values are used as dependent variables and are regressed on the framework variables.

proxy for the cost of capital seems to be less clear cut. Confer for example Schmiedel (2001) and Schmiedel, Malkamäki, and Tarkka (2006) who use a capital expenditures/book value-ratio and a OECD total information and communication technology expenditure/GDP-ratio, respectively. Furthermore, even if we considered the use of these proxies, this type of data was not available for all of the exchanges in our sample, because some of the exchange's home countries were not included in the the OECD-database and lacked the required capex-information.

[26] Confer Färe, Grosskopf, Norris, and Zhang (1994, p.68-75) and Fried, Lovell, and Schmidt (1993, p.50-53) for a more detailed discussion.

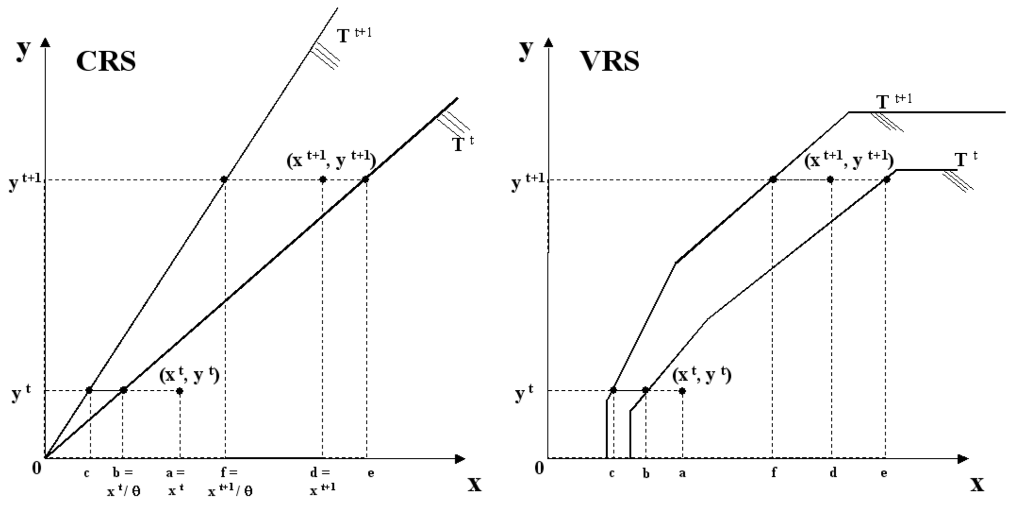

Figure 5.5: Input-oriented Malmquist approach for CRS and VRS

Using efficiency scores as dependent variable Using the DEA-scores as estimators of efficiency in a regression analysis entails the problem that they are truncated from above at a maximum value of one. Hence, instead of a regular OLS regression, which would produce biased results, we follow Dusansky and Wilson (1994) and McCarty and Yaisawarng (1993) who apply Tobit regressions in order to deal with truncated observations. Taking our panel data structure into account we estimate the following general Tobit model:

$$\begin{array}{rrcll} & EFF_{i,t} & = & X_{i,t}\beta + \epsilon_{i,t} & if \quad EFF^*_{i,t} < 1 \\ & EFF_{i,t} & = & 1 & if \quad EFF^*_{i,t} \geq 1 \\ where & \epsilon_{i,t} & = & \alpha_i + \eta_{i,t} & \end{array} \tag{5.1}$$

Here, $EFF_{i,t}$ is the efficiency score of exchange i in period t derived from the DEA-calculation, $EFF^*_{i,t}$ is the true but unobservable efficiency of exchange i in period t, $X_{i,t} = [1 \quad x']$ is an $((1 \times (K+1))$ vector of K framework variables plus one and β is a $((L+1) \times 1)$ vector of parameters. The error term is decomposed into an time-invariant individual effect of the exchange denoted as α_i and an independent effect $\eta_{i,t}$ which is assumed to be uncorrelated with $X_{i,t}$. Thus, we will employ a random effects model. The $K = 10$ framework variables used in this regression will be introduced and discussed in section 5.3.2. In total, we regress for $i = \{1, ..., n = 28\} \times t = \{1...T = 5\} = 140$ observations.

Using productivity values as dependent variable In a similar manner, we will regress the results from the factor productivity analysis on the same framework variables. The variables employed will then explain the impact on overall Malmquist factor productivity (MQ) as well as on the two decomposed effects, namely on the change in technical efficiency (ΔEFF) and on technological progress ($\Delta TECH$). Since there is no truncation in the productivity variables, we will employ standard panel regression equations. Thus, we obtain three regression models:

$$\begin{aligned}
MQ_{i,t} &= X_{i,t}\beta + \epsilon_{i,t} & (5.2)\\
\Delta EFF_{i,t} &= X_{i,t}\beta + \epsilon_{i,t} & (5.3)\\
\Delta TECH_{i,t} &= X_{i,t}\beta + \epsilon_{i,t} & (5.4)\\
where \qquad \epsilon_{i,t} &= \alpha_i + \eta_{i,t} \qquad respectively &
\end{aligned}$$

Here, $MQ_{i,t}$, $\Delta EFF_{i,t}$ and $\Delta TECH_{i,t}$ represent the values of Malmquist factor productivity, change in technical efficiency and technological progress of exchange i from period $t-1$ to period t, respectively. Again, $X_{i,t} = [1 \quad x']$ is a $((1 \times (K+1))$ vector of K framework variables plus one and β is an $((L+1) \times 1)$ vector of parameters. In these regressions we will use a fixed effects model, since the Hausman tests mostly reject the hypothesis that there is no systematic difference between the fixed and the random effects estimation - as we will see in section 5.3.3.2.[27] We will make use of the same $K = 10$ framework variables as in regression (5.1). Additionally, we will employ the calculated EFF-value of period $t-1$ of each exchange as a further independent variable in order to control for the fact that less efficient exchanges can potentially improve their productivity by a larger extent than highly efficient exchanges.[28] Since the dependent variables are calculated by comparing two adjacent periods, i.e. they consume data from periods t and t-1, we "lose" one period and have therefore four observations per DMU. Thus, we regress for $i = \{1, ..., n = 28\} \times t = \{1...(T-1) = 4\} = 112$ observations.[29]

5.3 Data and empirical results

5.3.1 The sample

The study employs a balanced panel data set that includes 28 stock exchanges for a five year time period (1999-2003) as can be seen in table 5.1. The sample encompasses five exchanges from the Americas, fourteen from Europe/Africa and nine from the Asia/Pacific region. All relevant accounting and transaction data have been converted into US-dollars on a purchasing power parity basis[30] and adjusted for inflation.[31] Although the sample lacks completeness of the whole exchange population, it does comprise about 85% of the total equity trading volume on stock exchanges reported to the FIBV.

In order to see how representative our sample is concerning the discussed business models, we re-present a modified version of figure 5.1, which shows the exchanges' related activities in our sample as a portion of the 50 largest trading venues worldwide. The filled areas of the bars represent the number of exchanges that are part of our sample. As can be seen, we included all exchanges that provide software services, whereas we incorporated more than half

[27] The Hausman specification test verifies whether the coefficients of a regression model with random effects are unbiased compared to the coefficients of a fixed effects model. The underlying assumption is that fixed effects models always produce consistent but potentially inefficient estimators, whereas a random effects model is always efficient but can be inconsistent. Confer for example Johnston and DiNardo (1997, p.403-404) for further details.

[28] Confer our explanation in footnote 10.

[29] In order to employ White-corrected estimators to control for cross-sectional heteroscedasticity we used EViews 5 as statistical package. For the random effects Tobit-regressions we utilized Stata 8.

[30] We acquired the PPP-data from World Bank World Development Indicators. In an earlier version we used data without the conversion on a PPP-basis. Therefore our results vary in some instances.

[31] The accounting data was acquired from the annual reports of the exchanges, whereas transaction and other descriptive data was obtained from the databases of the FIBV, the Federation of European Stock Exchanges, the HP Handbooks of World Stock, Derivatives & Commodity Exchanges, direct correspondence with the exchanges, and company web sites.

No.	Exchange	Region	Related Activities			5Y-Avg. World
			Post-Trading	Derivatives	Software	Market Share
1	BOVESPA	Americas	-	√	-	0.2%
2	Lima	Americas	-	2003-	-	0.0%
3	NASDAQ	Americas	-	-	-	25.7%
4	NYSE	Americas	-	-	-	25.1%
5	Toronto TSX	Americas	-	-1999	2002-	1.1%
6	Budapest	Europe/Africa	-	√	-	0.0%
7	Copenhagen	Europe/Africa	2000-	√	-	0.2%
8	Deutsche Börse	Europe/Africa	2000-	√	√	3.7%
9	Euronext†	Europe/Africa	√	√	√	7.7%
10	Hellenic*	Europe/Africa	2001-	2002-	2000-	0.2%
11	Istanbul	Europe/Africa	-	2001-	-	0.1%
12	Johannesburg JSE	Europe/Africa	√	2001-	-	0.2%
13	London	Europe/Africa	-	2003-	-	10.0%
14	Malta	Europe/Africa	√	-	-	0.0%
15	Oslo	Europe/Africa	-	√	-	0.2%
16	OM Gruppen	Europe/Africa	2001-	√	√	1.0%
17	SWX Zurich	Europe/Africa	-	√	-	1.5%
18	Vienna	Europe/Africa	2000-	√	-	0.0%
19	Warsaw	Europe/Africa	-	√	-	0.0%
20	Australian	Asia/Pacific	√	√	-	0.7%
21	Hongkong	Asia/Pacific	√	√	-	0.7%
22	Jakarta	Asia/Pacific	√	-	-	0.0%
23	Kuala Lumpur	Asia/Pacific	√	√	-	0.1%
24	Phillippine	Asia/Pacific	2003-	-	-	0.0%
25	Singapore SGX†	Asia/Pacific	√	√	2000-	0.2%
26	Taiwan	Asia/Pacific	√	-	-	1.8%
27	Thailand	Asia/Pacific	√	-	-	0.1%
28	Tokyo	Asia/Pacific	√	√	2002-	4.8%
	Total		17	20	7	**85.2%**

*: Athens Stock Exchange in 1999
†: Pro forma figures for 1999
√: Exchange possessed this activity since 1999 or earlier

Table 5.1: Sample of exchanges used in the analysis, 1999-2003

of the exchanges with derivatives trading and about a third of the exchanges with post-trading services. Hence, particularly exchanges with post-trading facilities are underrepresented in our sample. This is due to this group's relatively large portion of mutual exchanges - as was observable in figure 5.2. A substantial share of them is not obliged to disclose their annual reports to the public. Hence, we were not able to include these exchanges in our sample due to a lack of available comprehensive information.

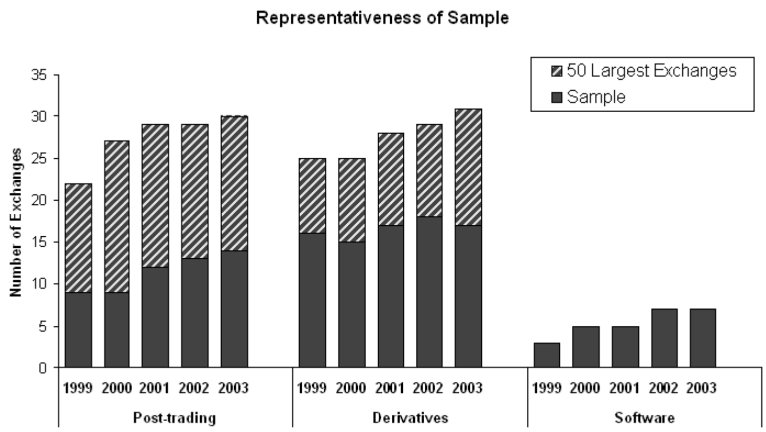

Figure 5.6: Representativeness of Sample

5.3.2 Variables

Table 5.2 provides an overview of the two different sets of variables employed in the analysis. They will be discussed in sections 5.3.2.1 and 5.3.2.2. Accompanying descriptive statistics on the variables are given in Appendix C.3.

	FIRST STAGE: Operational Variables
	Inputs
$\mathbf{x^1_{i,t}}$	Number of staff employed at exchange i in period t (year-end figures)
$\mathbf{x^2_{i,t}}$	Tangible assets at exchange i in period t (in thousand dollars)
	Outputs
$\mathbf{y^1_{i,t}}$	Number of listed companies at exchange i in period t
$\mathbf{y^2_{i,t}}$	Total trading volume in bonds and shares at exchange i in period t (in million dollars)
$\mathbf{y^3_{i,t}}$	Total number of derivatives contracts traded at exchange i in period t
$\mathbf{y^4_{i,t}}$	Post-trading services and software sales at exchange i in period t (in thousand dollars)
	SECOND STAGE: Framework Variables
	Business Model
$\mathbf{HORIZONTAL_{i,t}}$	Dummy variable indicating whether exchange i operates a derivatives platform in period t.
$\mathbf{VERTICAL_{i,t}}$	Dummy variable indicating whether exchange i provides post-trading services in period t.
$\mathbf{HORI-VERTICAL_{i,t}}$	Dummy variable indicating whether exchange i is both vertically and horizontally integrated in period t.
$\mathbf{FULL\ INTEGRATION_{i,t}}$	Dummy variable indicating whether exchange i is both vertically and horizontally integrated and also provides software services in period t.
$\mathbf{OUTSOURCING_{i,t}}$	Dummy variable indicating whether exchange i has outsourced its IT-system in period t.
	Governance
$\mathbf{LISTED_{i,t}}$	Dummy variable for publicly listed exchange i in period t.
	Competitive Position and Attractiveness of the Capital Market
$\mathbf{LIQUIDITY_{i,t}}$	Level of liquidity at exchange i in period t (year-end figures, in %). Liquidity = Trading volume in domestic equities/Market capitalization of domestic firms
$\mathbf{\Delta TRADING_{i,t}}$	Change in equity trading at exchange i relative to the sample from period t-1 to t. (year-end figures, in %)
$\mathbf{FOREIGN\ LISTING_{i,t}}$	World market share in new listings of foreign companies at exchange i in period t. Market share$_{i,t}$ = New foreign listings at exchange i in t/New foreign listings worldwide in t. (year-end figures, in %)
	Financial Flexibility
$\mathbf{\Delta LTFINANCE_{i,t}}$	Growth of equity and long term debt on exchange i's balance sheet from period t-1 to t. (book values, year-end figures, in %)
	Control Variable
$\mathbf{\Delta EFF_{i,t-1}}$	Corresponding efficiency values (CRS or VRS) of exchange i in period t-1.

Table 5.2: Variables used in the two-stage process

5.3.2.1 Operational variables

In the first stage, DEA-efficiency and Malmquist factor productivity calculations will be based on variables that are directly related to the operations of an exchange and can be influenced by the management. An appropriate choice of variables that represent the "production process" of an exchange is not a clear-cut task.[32] When considering plausible input variables, it seems

[32]Depending on the input and output variables incorporated in the calculation, the efficiency scores might have a bias towards certain DMUs. As an example, consider omitted output variables that only some DMUs in

sensible to cover both capital and labor aspects of the production process. Thus, labor will be approximated by the *number of staff* working for an exchange i in period t ($x^1_{i,t}$), whereas the utilization of capital for investments, such as the setup of an IT-infrastructure, a trading space, and the necessary buildings, are subsumed by the value of *tangible assets* employed at exchange i in period t ($x^2_{i,t}$).

On the output side, four different services are considered that can be 'produced' by an exchange. The variable $y^1_{i,t}$ stands for the *number of listed companies* at exchange i in period t. It will be used as a proxy for the exchange's effort to monitor the listed firms on the exchange in order to ensure fair trading and disclosure practices of company-specific information. Thus, the supervision of listed firms can be regarded as a service for trading participants to achieve market transparency. Secondly, the total *trading volume* in equities as well as in bonds will approximate the activities of exchange i on the cash market in period t ($y^2_{i,t}$).[33] Variable $y^3_{i,t}$ captures the total *number of derivative contracts* traded on the derivatives markets. Variable $y^4_{i,t}$ represents the *revenues from post-trading activities and software sales* at exchange i in period t.[34]

Before proceeding to the next section, a few words should be devoted to the choice of the proper DEA-model. Considering the employed inputs and outputs in this paper it makes sense to use an input-oriented DEA-model, since the number of staff and the value of tangible assets of an exchange can be more directly altered by the management than the level of demand for their products and services. Thus, the management's effort to reduce the exchange's inputs seems to be a fairer yardstick than its exertion to augment the venue's output levels.

5.3.2.2 Framework variables

The second stage now considers additional determinants arising from the framework in which an exchange is embedded and that may also have an influence on its performance. As noted by Fried, Lovell, and Schmidt (1993, p.53-54), the variables of the second stage may have an impact on the efficiency with which inputs are transformed to outputs, but they should not affect the production process itself. Thus, the authors require that the variables of the first and second stage are uncorrelated.[35] We will consider four types of factors that deserve particular attention and present corresponding variables that will function as proxies in our regressions. These are (1) the exchange's business model, (2) exchange's corporate governance regime, (3) the competitive environment and the attractiveness of the exchange's home capital market, and (4) the exchange's financial flexibility.[36]

the sample produce. If we cannot adjust the input variables of these DMUs accordingly in the sense that we merely include the amount of inputs devoted to the outputs considered in the calculation the unadjusted input value will be too high. We mitigate this problem by calculating efficiency and factor productivity scores for the broadest possible output-set, for it is easier to obtain information on additional outputs than to acquire a detailed breakdown of the used inputs and adjust them for the omitted outputs.

[33] The employment of the number of transactions performed on an exchange would have been a more precise measure of the activity. Unfortunately, this sort of data was not available for all 28 exchanges.

[34] The use of revenue numbers for the latter variable is not the most appropriate figure to be included in the output set. The number of clearing and settlement transactions serviced and the number of software systems sold would have been better proxies. However, due to the lack of this type of data for all exchanges in our sample, we opted for this procedure.

[35] However, for some of our variables we cannot maintain this point as can be seen in appendix C.5, where table C.4 displays the correlation among the employed variables. In particular the correlation between the first stage variables x^1, x^2, y^1, and y^2 with the second stage variables $FOREIGN\ LISTING$ and $LIQUIDITY$ is highly positive. Therefore our coefficient estimates may possess some bias. Nevertheless, our findings remain robust when we drop the latter variables from our regressions.

[36] Appendix C.5 also provides a correlation table for the variables of the second stage. We observe that the correlation among the framework variables is mostly moderate.

Business model As outlined in section 5.1, several exchanges extended their activities to other areas beyond the operation of a cash market. Some exchanges integrated horizontally, thereby providing an institutionalized derivatives trading venue. Others followed a vertical silo model by integrating post-trading services into the existing operations. Yet others are engaged as software-systems providers, most notably for other stock exchanges. As a consequence, there are several distinct business models present in this industry which could have varying effects on the exchanges' operative performance: On the one hand, the integration of certain activities could be beneficial due to potential synergies. Consider for example the combination of a cash and a derivatives market, which could be operated by a single trading system, and would therefore save (input) resources. In a similar fashion one could expect efficiency gains when trading and post-trading services are combined by utilizing a common transaction platform.[37] To test our hypotheses and thus for any differences in efficiency and factor productivity growth among these business setups, we will employ four dummy variables covering five distinct business models. We explicitly distinguish between (1) cash market-only operators and exchanges that operate (2) both a cash and a forward market, using a dummy variable denoted as HORIZONTAL (3) a cash market and post-trading facilities, employing a variable denoted as VERTICAL (4) a cash and a forward market as well as post-trading facilities by introducing a dummy denoted as HORI-VERTICAL and (5) all of these activities as well as a software sales division. Exchanges that fall under this category will receive a value of one at a dummy variable denoted as FULL INTEGRATION.[38]

Furthermore, some exchanges do not develop and operate their trading systems themselves but buy this service from an external provider. Thus, such an exchange rather incurs additional operating costs, which primarily materialize in the profit-loss statement and to a much lesser extent in its staff size and its tangible assets, which are the considered input factors in our analysis. Therefore, ignoring the outsourcing of IT-services would ceteris paribus result in a disadvantage for exchanges that develop their own trading system by employing staff and assets for that matter. Consequently, we need to control for this aspect. We do so by employing a dummy variable, denoted as OUTSOURCING, which equals one when the exchange under consideration outsources its trading system and zero otherwise. Since outsourcing ceteris paribus reduces the required input factors and hence increases the calculated efficiency values, we expect a positive coefficient sign at this variable.

Governance Stock exchanges vary in their governance regime. While some of them are still organized as mutuals, others have demutualized and gone public. Most notably, this resulted in differences in the type of owners that control the exchange. The latter group of exchanges is no more under the exclusive control of its customers, e.g. banks and brokers, but is primarily influenced by outside investors, whose profit-maximization or - by the same token - cost-minimization motive may not always be shared by the customers. As a result, we may observe an impact of the governance and ownership structure on how efficient an exchange operates, which we would like to control for. Hence, we employ a dummy variable, denoted as LISTED, for those exchanges that are publicly listed and are therefore subject to outside

[37]Confer Serifsoy and Weiss (2007) for a discussion on the European securities transaction industry from an industrial organization perspective.

[38]Other combinations of business models such as "cash market and software" or "cash and derivatives market and software" were omitted, since their respective subsample sizes were too small to draw inferences. As a consequence, some of the exchanges had to be subsumed in other categories: We assigned the Toronto Stock Exchange under "cash only"-operator in 2002 despite their operations in software sales. In an analogous manner we subsumed the OM-Gruppen (in 1999-2000) and the Deutsche Börse (in 1999) to the HORIZONTAL-variable although both firms possessed a software division in the indicated periods. Finally, we assigned the Hellenic Exchange to the VERTICAL-variable in 2000 and 2001 with the same reasoning.

ownership and control. Some authors emphasize the importance of being publicly listed in order to operate efficiently.[39] Therefore, we expect a stronger performance by outsider-dominated exchanges.

Competition and attractiveness of capital market The degree of competitive pressure that an exchange is exposed to may have an influence on the operative efficiency and factor productivity of exchanges. We employ three variables that capture distinct aspects of competition in this industry.

Our first variable, denoted as LIQUIDITY, measures the *depth* of the market operated by an exchange and thereby provides a proxy for an exchange's importance and market power vis-à-vis other exchanges. A common way to calculate the existing level of liquidity on an exchange's trading platform is to divide the annual (equity) trading volume by the market capitalization of the firms listed on the exchange.

The second variable, denoted as ΔTRADING, proxies an exchange's *performance* capturing annual changes in the competitive position. To operationalize, we employ year-on-year (y-o-y) changes in equity trading volume at an exchange. In order to control for broader market movements we deduct the median y-o-y change of the whole sample from each exchange's performance in the respective period. The rationale behind this procedure is the following: A relative gain in trading volume, indicating that the exchange was able to capture more trading volume than the median exchange of the sample, signals a relatively strong competitive position as opposed to other exchanges. By contrast, a relative loss in trading volume would suggest a deterioration in the competitive position.

Our third variable, denoted as FOREIGN LISTING captures the general *attractiveness* of the exchange's home capital market by calculating an exchange's market share in new foreign firms listings as a percentage of the total new foreign listings worldwide. We believe that this describes the general attractiveness of a capital market quite well, since there are mainly two reasons for firms to list abroad: Either the firm is forced to, for its home capital market is not attractive, or it seeks funds from a foreign capital market in order to tap into an additional large and attractive pool of potential investors.[40]

When we regress the technical efficiency and productivity of an exchange on these variables, it is difficult to establish an ex ante expectation concerning the theoretically correct sign of the coefficients. Both directions seem plausible. Consider for example the LIQUIDITY-variable: An exchange with a relatively deep market can be considered to possess a strong competitive position which may result in a better exploitation of its resources and thus in higher efficiency. The contrary may also hold as monopolistic inertia symptoms could cause excessive (input) spending and contribute to lower efficiency values. An analogous reasoning can be established for the coefficient's sign of the FOREIGN LISTING-variable. The ΔTRADING-variable may also display differing signs: It could have a positive sign when the relative loss in trading volume causes a decrease in efficiency. This will be the case when unfavorable market conditions coincide with lower absolute equity trading volumes, since this will negatively affect the level of the DEA-output variable $y^2_{i,t}$ and thus ceteris paribus a decrease of the efficiency value. Yet, the sign could also be negative when a relative loss in trading volume means that the exchange overcompensates this by a disproportionate reduction in the input variables and thereby achieves higher efficiency values. By the same token a DMU could spend overly much in its inputs than

[39] Confer for example OECD (2003) and Scullion (2001).

[40] Support for this notion can be found in an empirical paper on cross-listings by Pagano, Randl, Röell, and Zechner (2001) who find that firms seeking cross-listing tend to choose foreign capital markets with large and liquid markets as well as where investor protection and efficiency of courts are high.

the increase in trading volume would allow.

Financial flexibility In reality we observe that several exchanges raised external funds in order to finance the modernization of their trading venues or to pursue other projects that were aimed to boost their competitiveness.[41] Thus, the financial flexibility of an exchange, i.e. its ability to raise new funds to finance investments may also have an effect on an exchange's efficiency and factor productivity growth, albeit it remains ex ante unclear whether it has a positive or an adverse one. On the one hand, the capability of acquiring new proceeds could be a necessary prerequisite to induce efficiency-enhancing investments. On the other, it could lead to inefficiencies due to overinvestments resulting from too abundant funds. We employ a variable which seeks to capture the exchange's inflow of new proceeds in long term capital in each period. Ideally, we would measure this by using the respective cash flow statements of each exchange in order to capture the actual capital inflow. However, these figures are not available for all exchanges. Hence, we use a less accurate means and employ a variable denoted as ΔLT FINANCE, which denotes the annual change in equity and long-term debt as is stated in the exchanges' balance sheets.[42]

5.3.3 Results

5.3.3.1 Results from the first stage

In Appendix C.4, table C.2 presents the first-stage results of the DEA-efficiency and Malmquist-productivity analysis for both constant and variable returns-to-scale.[43] The results of the efficiency scores indicate that six exchanges, namely Nasdaq, Toronto, Copenhagen, Deutsche Börse, Euronext and Malta, are fully efficient in all five considered periods in the VRS-case, whereas there are only two such cases in the CRS-environment (Copenhagen and Euronext). Furthermore, average technical efficiency for the whole sample lied between 0.58 and 0.66 in the CRS-case and between 0.70 and 0.77 in the VRS-case. As expected, average efficiency was higher in the latter case due to the closer envelopment of the data.

Both underlying technologies display an overall increase in average factor productivity growth with strong rises in the 2000/2001 (CRS: 9%, VRS: 8%) and 2002/2003-period (CRS:11%, VRS: 8%), whereas the 2001/2002-period witnesses an overall stagnation in productivity growth. The most remarkable individual increase is accomplished by the Brazilian exchange BOVESPA, which improved its efficiency from 0.53 and 0.57 in 1999 to full efficiency in 2003 for the respective settings.

5.3.3.2 Results from the second stage

Table 5.3 displays the results from the regression analysis using the first stage results, i.e. DEA-efficiency (EFF), Malmquist-productivity (MQ), change in technical efficiency (ΔEFF) and progress in technology (ΔTECH), as dependent variables as was outlined in section 5.2.2.

The table is divided into two panels. The left panel displays the results for constant returns-to-scale. The right panel provides our estimates when assuming variable returns-to-scale. We

[41] Most explicitly this has occurred at exchanges that went public but one can imagine that - irrespective of the governance - fresh capital was provided for the exchanges to better cope with increased competitive pressure.

[42] In order to prevent distortions from currency fluctuations we use inflation-adjusted book values of the exchanges' home currencies.

[43] We are grateful to Holger Scheel whose program 'EMS' we utilized for the calculation of the efficiency and productivity scores.

	Constant Returns-To-Scale				Variable Returns-To-Scale			
(1)	(2) EFF	(3) MQ	(4) ΔEFF	(5) ΔTECH	(6) EFF	(7) MQ	(8) ΔEFF	(9) ΔTECH
HORIZONTAL	-0.072	-0.096	-0.037	-0.027	-0.120†	-0.003	-0.005	-0.012
Std. Err.	*0.052*	*0.074*	*0.090*	*0.164*	*0.080*	*0.059*	*0.106*	*0.151*
VERTICAL	-0.054	0.555	0.754†	-0.012	-0.209***	0.503	0.728†	-0.120*
Std. Err.	*0.080*	*0.457*	*0.497*	*0.106*	*0.082*	*0.410*	*0.503*	*0.074*
HORI-VERTICAL	-0.026	0.151*	0.265***	-0.009	-0.204***	0.170***	0.339***	-0.168†
Std. Err.	*0.064*	*0.092*	*0.077*	*0.066*	*0.084*	*0.042*	*0.066*	*0.106*
FULL INTEGRATION	-0.053	0.021	0.102	-0.018	-0.192**	0.130†	0.157	-0.060
Std. Err.	*0.073*	*0.052*	*0.091*	*0.074*	*0.103*	*0.084*	*0.128*	*0.088*
OUTSOURCING	0.012	0.086	-0.017	0.169***	0.170***	0.036	-0.036	0.121***
Std. Err.	*0.073*	*0.274*	*0.271*	*0.047*	*0.053*	*0.234*	*0.252*	*0.015*
LISTED	0.063	0.093	-0.063†	0.167**	0.087†	0.066	-0.061	0.136†
Std. Err.	*0.047*	*0.100*	*0.040*	*0.070*	*0.055*	*0.111*	*0.062*	*0.083*
LIQUIDITY	-0.007	-0.041	-0.004	-0.057	-0.052	-0.031***	0.036	-0.060
Std. Err.	*0.032*	*0.039*	*0.104*	*0.092*	*0.037*	*0.002*	*0.047*	*0.060*
ΔTRADING	0.030	-0.127***	-0.122***	0.004	0.059	-0.115***	-0.121***	0.011
Std. Err.	0.033	0.021	0.042	0.081	0.043	0.015	0.019	0.039
FOREIGN LISTING	1.004**	1.251†	1.210*	0.213	1.559**	0.688	1.146**	-0.538
Std. Err.	*0.435*	*0.816*	*0.692*	*0.583*	*0.663*	*0.737*	*0.462*	*0.907*
ΔLT FINANCE	0.035	-0.092***	-0.023	-0.075	0.029	-0.080**	-0.042	-0.050
Std. Err.	*0.031*	*0.021*	*0.051*	*0.072*	*0.038*	*0.035*	*0.047*	*0.057*
EFF		-1.370**	-1.827***	0.533***		-0.984***	-1.543***	0.555***
Std. Err.		*0.617*	*0.609*	*0.092*		*0.350*	*0.459*	*0.118*
CONST	0.661***	1.806***	1.979***	0.728***	0.916***	1.638***	1.915***	0.725***
Std. Err.	*0.052*	*0.363*	*0.458*	*0.105*	*0.086*	*0.272*	*0.432*	*0.144*
Observations	140	112	112	112	140	112	112	112
R^2(adj.)/Waldχ^2	22.08	0.309	0.323	-0.165	49.30	0.305	0.405	0.033
Hausman Test (p)	-	0.0008	0.0000	0.3663	-	0.0078	0.0000	0.0277

†, *, **, ***, represent 15%, 10%, 5% and 1% significance levels, respectively.

Table 5.3: Results from the second-stage regression analysis

numerated the columns (1-9) for convenience. Overall, the adjusted R^2-values of the productivity regressions are reasonable, save for the less appealing values in columns five and nine. We therefore will primarily draw our conclusions from the remaining regressions. When comparing the individual coefficients between the two panels we find that their signs, if they are significant, do not change. The results of the Hausman test demonstrate that a random effects model is likely to produce inconsistent estimates for our regressions in all but one case (column five), since the p-values display a significant rejection of the null-hypothesis. Thus, the use of a fixed effects model is more appropriate.

Results for our hypotheses Our business model variables suggest that the integration of related activities does not enhance technical efficiency. In the contrary: While in the CRS-case we cannot observe any significant difference, all our variables indicate a relatively strong underperformance in the VRS-case, as can be seen in column six. Our VERTICAL, HORI-VERTICAL and FULL INTEGRATION variable all display technical efficiencies that are on average 20 percent lower than for exchanges that are focused on the cash trading activity. A similar pattern can be observed for exchanges that are horizontally integrated. However, the negative coefficient of the HORIZONTAL-variable is merely about half as large (-0.12) and is only weakly significant.

As far as overall productivity growth is concerned, the more complex business models seem to fare better than exchanges that are focused on the cash market. In the HORI-VERTICAL case, for example, we witness a significantly stronger growth than at cash trading-only exchanges. The outperformance amounts to 15.1% and 17%, depending on the considered technological environment. The main source of the strong productivity growth is attributable to improvements in technical efficiency (ΔEFF), since the coefficient here is strongly positive in both technological setups. In the FULL INTEGRATION case, overall productivity seems to be higher by 13 percentage points in the VRS-environment.

Exchanges that are merely vertically integrated (VERTICAL), possess the largest positive coefficients, with 55% in the CRS-case and 50.3% in the VRS-environment. Even though the coefficients are not significant in the regression results shown here, they turn significant when using bootstrapped standard errors[44], so that we presume that there exists an outperformance by this business model with respect to factor productivity.

Therefore, we conclude that none of our stated hypotheses can be fully confirmed, since the integration strategies do not seem to result in higher technical efficiency for the exchanges. However, the second component of each hypothesis, i.e. factor productivity growth, seems to be stronger in those cases where exchanges are diversified into post-trading activities.

Interpreting the results of the business model variables The results from the business model variables indicate that a combination of activities is not necessarily efficiency-enhancing. In the contrary, exchanges that merely focus on cash-markets seem to perform superior vis-à-vis certain other setups, when we assume a variable returns-to-scale environment. A possible reason why for example the additional provision of derivatives trading creates technical inefficiencies could be related to the inability of the exchanges to integrate this activity in a resource saving manner. As the Economist noted recently, most exchanges offering cash and derivatives trading have not yet consolidated these services onto a single platform.[45] Instead, the exchanges usually provide cash and derivatives trading on two separate platforms, which adds to the complexity of the business process on the one hand, and does not take advantage of potential cost synergies on the other. An analogous reasoning can be established for vertically integrated exchanges.

Another explanation could be that integration activities take time until the benefits of the combination are realized. As we pointed out in figure 5.1, some of the exchanges diversified into related activities during our considered time period. If this is accompanied by substantial set up costs or operational frictions, it may lead to an initial underperformance in operative efficiency.[46] To analyze this notion, we took a closer look at the development in operating costs and in technical efficiency of the subsample of exchanges that diversified into post-trading, derivatives trading, or software services during the considered period. We indexed the costs in the year of diversification activity of each exchange and aligned them at the 'event' period t.[47] The left panel of figure 5.7 displays the indexed operating costs and technical efficiency of the

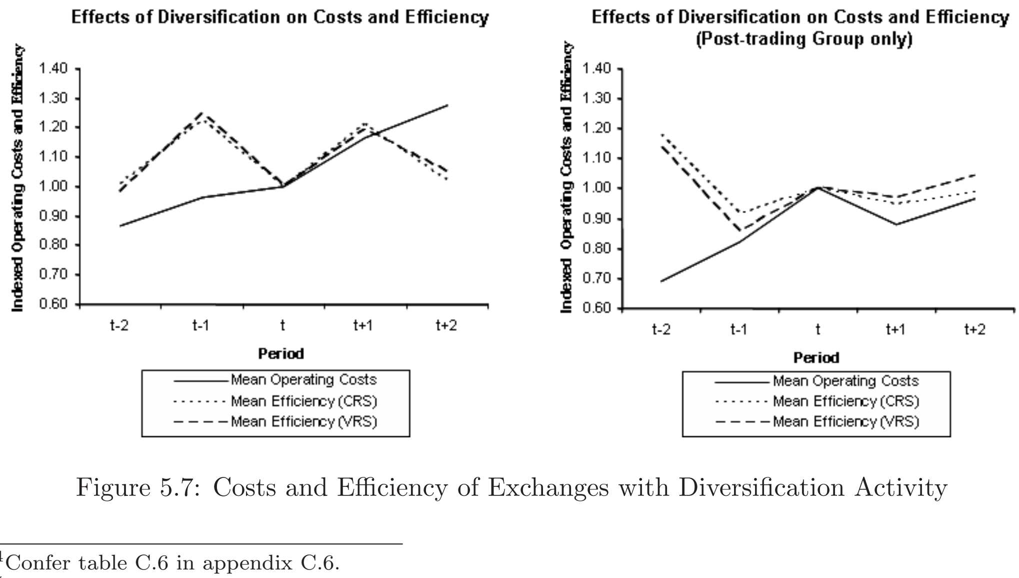

Figure 5.7: Costs and Efficiency of Exchanges with Diversification Activity

[44]Confer table C.6 in appendix C.6.

[45]Confer Economist (2005).

[46]We thank one of the referees for this suggestion.

[47]We used those exchanges that invested into new activities during 1999 and 2003 as indicated in table 5.1. In a prior analysis, we additionally adjusted the calculated values by the corresponding development of a control group sample, which did not diversify into related activities in the considered time period. Since the results remain virtually unchanged, we decided to show the unadjusted results to keep the exposition simple.

considered sample of exchanges for the periods t-2 until t+2, where the 'event' of diversification occurs at period t. We observe that average costs (solid line) did indeed rise at the event and afterwards. At the same time, technical efficiency (dotted and dashed line) displays an m-shaped development, with a higher efficiency scores directly before and after period t. Since efficiency values decreased in t-2 and t+2 in a similar fashion as in period t, we cannot confirm a particularly negative impact on efficiency due to the event of diversification. Furthermore, for the subgroup of exchanges with new post-trading activities shown in the right panel, we observe an even weaker negative impact by the integration strategy. While average operating costs rose sharply until period t, which is an indicator that the acquisition of a post-trading institution demanded considerable firm resources, they did not rise further after the event. Also, technical efficiency did not seem to be overly affected by this type of integration. In fact, efficiency rose at the event period and remained relatively stable thereafter. We conclude that while operating costs increased substantially, the operative performance did not seem to be strongly influenced in an adverse manner by the change in the business model.

Influence of control variables We briefly want to discuss the results from our control variables. From our OUTSOURCING variable we infer that outsourcing substantially increases technical efficiency by 17 percentage points in the VRS-case, whereas we cannot observe any significant effect in the CRS-case. Furthermore, overall productivity (columns two and five) does not seem to be overly affected by this strategy, since it displays no significant effect (columns three and seven).

We only find weak evidence that publicly listed exchanges possess a higher efficiency than mutual exchanges. While the CRS-case in column (2) does not display any significant difference for the LISTED-variable, we observe a 8.7% higher efficiency on the 15%-level in the VRS-case (column six). We conclude that outside ownership does not seem to overly contribute to a higher operative efficiency. A somewhat similar picture presents our Malmquist factor productivity measures in columns three and seven. In both cases, overall productivity is not significantly larger for listed exchanges. When focusing on the two components of productivity growth. we observe that listed exchanges have a significantly higher technological progress as can be seen in columns five and nine, but perform relatively worse in improving technical efficiency (columns four and eight). As a consequence, the resulting aggregate effect for productivity growth is not significantly different from those of mutual exchanges.

The impact of variables representing the competitive environment on exchange efficiency is insignificant except for the FOREIGN LISTING-variable. Here we see a significantly positive impact of the variable on technical efficiency in both technological environments (columns two and six). This implies that exchanges that possess an attractive home capital market also seem to be more efficient. As far as MQ-productivity growth is concerned, we observe that our ΔTRADING variable displays a significantly negative sign in both the CRS and VRS-case, which can be seen in columns three and seven. We conclude that an above average loss in trading volume seems to lead to an additional input reduction effort by the management to boost productivity growth. The decomposition of productivity growth indicates that in both technological environment it is mainly driven by stronger improvements in technical efficiency (ΔEFF), as can be observed in columns four and eight.

Our variable representing the financial flexibility of an exchange, ΔLT FINANCE, displays no significant effect on the technical efficiency of exchanges. However, more available funds apparently lead to lower overall productivity growth in both the CRS and VRS-case.

The control variable EFF shows that productivity growth is lower for exchanges that possess higher efficiency values (columns two and five). Thus, productivity gains are easier to accomplish for exchanges with lower efficiency values.

Robustness of findings To provide more validity to our results, in particular of our findings on the business model variables, we conducted some robustness checks. Table C.5 in appendix C.6 displays the results when using the simple efficiency measures Cash Volume/Assets and Cash Volume/Staff[48] as dependent variables as well as taking the annual percentage changes of these ratios (ΔCash Volume/Assets and ΔCash Volume/Staff) as productivity growth measures. We find that the efficiency measures produce somewhat similar results for our business model variables, although there is a contradictory outcome for our VERTICAL variables. While column one displays a significantly negative coefficient, the same variable in column two possess a significantly positive coefficient. In a similar manner, the two productivity measures are contradicting each other. The coefficients of the variables VERTICAL, HORI-VERTICAL, and FULL INTEGRATION all possess significantly different signs (columns three and four). Therefore, we cannot infer any reliable indications from these measures.

Furthermore, we verified our regression results presented in table 5.3 by using bootstrapped standard errors.[49] As can be seen in table C.6, our bootstrapped results largely confirm the significance of our efficiency estimates in columns two and six. For our overall MQ-productivity growth, we observe that the coefficient of the VERTICAL variable turns significant in both technological settings in columns three and seven, implying that the large coefficient value of 50.2-55.5% is indeed statistically significant. On the other hand, the outperformance in productivity growth at the HORI-VERTICAL and FULL INTEGRATION variables is not significant any more. Overall, we would state that our robustness checks confirm our main result that diversified exchanges are less efficient than focused firms. We only find evidence that vertically integrated exchanges seem to possess a larger productivity growth than focused exchanges, whereas exchanges with more than one related activities neither seem to be able to outperform in terms of technical efficiency nor in factor productivity growth.

5.4 Conclusion

This paper discussed the ongoing trend of business diversification within the stock exchange industry for the years 1999 to 2003 and sought to measure potential differences in technical efficiency and factor productivity growth that are attributable to differing business models. We noticed that most of the integration activity in these years was conducted by profit-oriented, demutualized exchanges, whereas mutual exchanges largely focused on their existing operations, save for a few entities that diversified into derivatives trading activities. We presume that the reason for these different patterns lie in the diverging ownership structures and the resulting objective functions of the exchanges. While profit-oriented, particularly publicly listed stock exchanges, substantially rely on revenues from related business activities such as post-trading services, derivatives trading or software sales, we find only little evidence that the integration of these activities also leads to better results in efficiency and factor productivity growth compared to exchanges that focus on cash market operations. Although some potential for efficiency

[48] Because of the wide dispersion in the distribution of efficiency values - Copenhagen is more than 1300times more efficient than Malta according to this measure - we used log values in the regressions.

[49] In particular, we replicated a random drawing with replacement from our sample 2000 times in order to derive a frequency distribution of coefficient estimates that allows us to estimate a sample-specific standard error. Furthermore, we constructed 85% and 90%-confidence intervals by using the 5%, 7.5% and the 92.5%, 95% percentiles of the distribution, respectively. We also controlled for our panel data structure by using clusters. Confer Bradley and Tibshirani (1993) for an elaborate discussion on bootstrapping.

improvements should be possible due to synergies between certain activities, this cannot be observed. Counterproductive effects such as increased business process complexity seem to dominate the overall effect on efficiency leading to a worse performance as opposed to cash market-only operators.

It seems that the diversification strategy of profit-oriented exchanges was not driven by efficiency-enhancement motives. However, this does not imply that these exchanges should not diversify into related businesses. We deliberately considered only technical efficiency in order to ensure a better comparability between for-profit and not-for-profit entities. Hence, the analysis of economic efficiency, a measure which is more relevant for for-profit firms, may produce different results. Therefore, the integration of related activities may still prove to be a profitable investment as long as positive excess rents can be earned in these fields. In fact, stock exchanges that diversified into derivatives and post-trading seem to have increased their profitability substantially, as can be seen in the case of the Deutsche Börse, which increased its operating profits by more than 16-fold from 1999 to 2003. Furthermore, diversification may also be used to reduce business risks.[50]

Finally, our analysis also touches the much discussed topic, whether vertical integration is beneficial or detrimental to social welfare. As indicated in the introduction, a significant outperformance of a vertically integrated business model for our considered measures would offer proponents of this business model a plausible justification. Our findings, however, provide only partial support at best. On the one hand, technical efficiency seems to be actually lower for exchanges with a vertical business model. On the other hand, we find some evidence that vertically integrated exchanges have a stronger factor productivity growth than focused exchanges. However, it still remains to be analyzed how these exchanges perform relative to two entities providing cash trading and post-trading, separately, in order to be more conclusive in this respect.

[50] In the extreme, this policy may not even be in the interest of the exchange but rather of risk-averse managers as described by Amihud and Lev (1981) for conglomerates in general.

Appendix A

Chapter 3

A.1 Descriptive Statistics

Operational Variables

INPUTS	x1 Staff (No. Employed)		x2 Tangible Assets ($ 000)	
	Mean	Std. Dev.	Mean	Std. Dev.
1999	558.5	494.4	52,131	74,936
2000	591.0	503.3	58,622	85,873
2001	615.0	529.7	69,657	94,969
2002	682.3	720.6	74,925	104,044
2003	658.1	696.8	79,959	107,562

OUTPUTS	y1 Listing (No. of companies)		y2 Cash Trading (Volume in $ 000 000)		y3 Derivatives Trading (No. of contracts in 000)		y4 Settlement/Software ($ 000)	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
1999	858.1	1071.1	1,432,736	2,629,916	26,430	76,181	20,228	45,169
2000	876.3	1056.7	1,942,741	4,208,753	33,024	89,092	27,044	56,448
2001	817.5	924.7	1,359,079	2,842,350	47,298	124,285	31,500	65,918
2002	797.9	868.3	1,248,960	2,446,333	63,260	174,780	46,235	111,907
2003	901.2	1007.3	1,219,142	2,321,408	74,936	198,740	66,019	179,856

Resulting Dependent Variables for the Second Stage

	EFF (CRS)		EFF (VRS)	
	Mean	Std. Dev.	Mean	Std. Dev.
1999	0.613	0.289	0.685	0.287
2000	0.642	0.293	0.724	0.275
2001	0.632	0.271	0.754	0.260
2002	0.610	0.286	0.766	0.297
2003	0.586	0.328	0.666	0.314

	MQ (CRS)		ΔEFF (CRS)		ΔTECH (CRS)	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
1999-2000	1.067	0.263	1.088	0.293	0.761	0.273
2000-2001	1.021	0.288	1.034	0.295	0.992	0.079
2001-2002	0.994	0.188	0.967	0.222	1.049	0.168
2002-2003	1.141	0.259	0.938	0.261	1.248	0.203

	MQ (VRS)		ΔEFF (VRS)		ΔTECH (VRS)	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
1999-2000	1.086	0.240	1.105	0.271	0.997	0.138
2000-2001	1.009	0.241	1.104	0.343	0.992	0.079
2001-2002	0.998	0.123	0.993	0.187	1.049	0.168
2002-2003	1.077	0.213	0.893	0.191	1.248	0.203

Independent Framework Variables of the Second Stage

	DEMUT	LISTED	OUTSOURCING	HORIZONTAL	VERTICAL
	Sum	Sum	Sum	Sum	Sum
1999	6	2	5	11	4
2000	11	5	7	10	5
2001	15	8	7	10	5
2002	17	9	8	9	4
2003	17	9	7	7	4

	FOREIGN LISTING		LIQUIDITY		FULL INTEGRATION
	Mean	Std. Dev.	Mean	Std. Dev.	Sum
1999	0.026	0.046	0.680	0.535	5
2000	0.031	0.071	1.038	1.103	5
2001	0.028	0.058	0.812	0.746	7
2002	0.028	0.059	0.881	0.772	9
2003	0.013	0.021	0.699	0.518	10

	Δ LT FINANCE		Δ TRADING	
	Mean	Std. Dev.	Mean	Std. Dev.
1998-1999	0.416	0.899	0.130	0.614
1999-2000	0.165	0.271	0.030	0.515
2000-2001	0.286	0.392	-0.006	0.292
2001-2002	0.095	0.240	0.035	0.275
2002-2003	0.079	0.273	0.101	0.388

Table A.1: Descriptive Statistics for Employed First and Second Stage Variables

A.2 First Stage Results

	Constant-Returns-To-Scale								
	DEA Technical Efficiency					Malmquist Prod. Index			
	1999	**2000**	**2001**	**2002**	**2003**	**99-00**	**00-01**	**01-02**	**02-03**
NASDAQ	1.00	1.00	0.78	0.64	0.72	1.00	0.79	0.81	1.23
NYSE	0.45	0.49	0.66	0.60	0.49	1.00	0.95	0.97	0.95
Toronto TSX	0.74	0.79	0.53	0.72	1.00	0.97	0.71	1.43	1.80
Lima	0.87	1.00	1.00	1.00	0.81	1.06	1.06	1.04	1.05
BOVESPA	0.34	0.50	0.61	0.89	1.00	1.44	1.37	1.23	1.32
Hellenic	0.55	1.00	0.45	0.28	0.35	1.68	0.44	0.78	1.69
Budapest	0.23	0.24	0.47	0.48	0.66	1.10	1.86	0.65	1.50
Copenhagen	1.00	1.00	1.00	1.00	1.00	1.00	0.92	1.00	1.00
Deutsche Börse	1.00	1.00	1.00	0.70	1.00	1.00	1.00	0.83	1.64
Euronext	1.00	1.00	1.00	1.00	1.00	1.05	1.00	1.00	1.00
Istanbul	0.17	0.20	0.20	0.14	0.11	1.06	0.92	0.74	1.07
Johannesburg JSE	1.00	0.81	0.72	0.72	0.41	0.88	0.83	0.89	0.73
London	0.83	0.97	1.00	1.00	1.00	0.98	1.06	1.00	1.01
Malta	0.41	0.22	0.18	0.17	0.14	0.69	0.82	1.22	1.09
Oslo	0.67	0.71	0.70	0.50	0.37	1.01	0.96	0.69	0.97
OM Gruppen	0.91	0.60	1.00	1.00	1.00	1.01	1.67	0.98	1.00
SWX Zurich	0.69	1.00	0.78	1.00	1.00	1.59	0.84	1.08	1.08
Vienna	0.36	0.37	0.36	0.44	0.26	0.98	0.97	1.25	1.01
Warsaw	0.31	0.32	0.24	0.23	0.18	0.92	0.80	0.96	1.07
Australian	0.90	0.93	0.82	0.85	0.65	1.01	0.94	1.13	1.12
Hongkong	0.42	0.76	0.70	0.54	0.45	1.79	0.88	1.02	1.14
Jakarta	0.33	0.32	0.37	0.48	0.69	0.91	1.05	1.15	1.28
Kuala Lumpur	0.39	0.36	0.43	0.23	0.21	0.92	1.16	0.69	1.26
Philippine	0.45	0.52	0.46	0.44	0.26	1.07	0.95	0.99	1.04
Singapore SGX	1.00	0.57	0.66	0.50	0.26	0.58	1.08	1.06	0.69
Taiwan	0.23	0.28	0.30	0.33	0.24	1.10	1.07	1.16	1.04
Thailand	0.38	0.37	0.38	0.37	0.32	0.97	0.98	0.95	0.95
Tokyo	0.50	0.64	0.90	0.84	0.81	1.08	1.51	1.12	1.22
Mean	0.61	0.64	0.63	0.61	0.59	1.07	1.02	0.99	1.14
Standard Deviation	0.29	0.29	0.27	0.29	0.33	0.26	0.29	0.19	0.26

	Variable-Returns-To-Scale								
	DEA Technical Efficiency					Malmquist Prod. Index			
	1999	**2000**	**2001**	**2002**	**2003**	**99-00**	**00-01**	**01-02**	**02-03**
NASDAQ	1.00	1.00	1.00	1.00	0.72	1.00	0.90	0.94	1.00
NYSE	0.57	0.63	1.00	1.00	0.49	1.31	0.93	0.97	0.98
Toronto TSX	1.00	1.00	0.56	1.00	1.00	1.00	0.58	1.00	1.52
Lima	0.99	1.00	1.00	1.00	1.00	1.03	1.06	1.03	1.03
BOVESPA	0.36	0.53	0.64	0.94	1.00	1.41	1.26	1.22	1.25
Hellenic	0.67	1.00	0.45	0.28	0.37	1.51	0.45	0.75	1.66
Budapest	0.44	0.77	1.00	1.00	1.00	1.32	1.24	1.00	1.01
Copenhagen	1.00	1.00	1.00	1.00	1.00	1.00	0.94	1.00	1.00
Deutsche Börse	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.37
Euronext	1.00	1.00	1.00	1.00	1.00	1.03	1.00	1.00	1.00
Istanbul	0.19	0.22	0.25	0.16	0.13	1.09	0.84	0.74	0.97
Johannesburg JSE	1.00	1.00	1.00	1.00	0.45	0.95	0.94	1.00	0.54
London	0.85	0.97	1.00	1.00	1.00	0.99	1.02	1.00	1.00
Malta	1.00	1.00	1.00	1.00	1.00	0.90	0.96	0.99	0.98
Oslo	0.83	0.76	0.73	0.54	0.51	0.95	0.96	0.73	1.05
OM Gruppen	0.92	0.60	1.00	1.00	1.00	1.00	1.66	0.98	1.00
SWX Zurich	0.70	1.00	0.79	1.00	1.00	1.54	0.85	1.08	1.08
Vienna	0.53	0.57	0.62	0.68	0.63	1.00	0.95	1.16	1.02
Warsaw	0.32	0.32	0.25	0.24	0.24	0.92	0.81	1.00	1.12
Australian	0.94	1.00	1.00	1.00	0.66	1.04	0.98	1.04	1.07
Hongkong	0.43	0.76	0.71	0.59	0.46	1.78	0.88	1.04	1.15
Jakarta	0.35	0.32	0.72	0.82	0.69	0.91	1.37	1.15	1.26
Kuala Lumpur	0.39	0.37	0.44	0.29	0.22	0.92	1.14	0.78	1.23
Philippine	0.53	0.52	0.47	0.45	0.42	1.04	0.96	1.00	1.02
Singapore SGX	1.00	0.58	0.66	0.50	0.27	0.59	1.08	1.06	0.70
Taiwan	0.26	0.33	0.46	0.49	0.25	1.15	1.04	1.16	1.04
Thailand	0.39	0.38	0.42	0.46	0.32	0.97	1.00	0.97	0.96
Tokyo	0.51	0.64	0.93	1.00	0.81	1.08	1.46	1.11	1.12
Mean	0.68	0.72	0.75	0.77	0.67	1.09	1.01	1.00	1.08
Standard Deviation	0.29	0.27	0.26	0.30	0.31	0.24	0.24	0.12	0.21

Table A.2: First Stage Results

A.3 Correlation matrix

Efficiency Regression Variables	$\mathbf{x^1}$	$\mathbf{x^2}$	$\mathbf{y^1}$	$\mathbf{y^2}$	$\mathbf{y^3}$	$\mathbf{y^4}$
DEMUT	0.160	0.118	0.110	-0.009	0.223	0.290
LISTED	0.309	0.084	0.085	-0.051	0.308	0.422
LIQUIDITY	0.320	0.394	0.502	0.579	0.163	0.110
ΔTRADING	0.007	-0.003	0.084	0.081	-0.070	-0.057
FOREIGN LISTING	0.363	0.602	0.698	0.866	0.017	-0.018
ΔLT FINANCE	-0.013	-0.065	-0.066	0.011	0.056	0.016
OUTSOURCING	-0.379	-0.172	-0.180	-0.081	-0.189	-0.185
HORIZONTAL	-0.402	-0.327	-0.338	-0.239	0.008	-0.223
VERTICAL	-0.175	-0.185	-0.236	-0.189	-0.138	-0.094
FULL INTEGRATION	0.515	0.120	0.068	-0.074	0.300	0.505
Productivity Regression Variables	$\mathbf{x^1}$	$\mathbf{x^2}$	$\mathbf{y^1}$	$\mathbf{y^2}$	$\mathbf{y^3}$	$\mathbf{y^4}$
DEMUT	0.188	0.109	0.074	-0.022	0.221	0.351
LISTED	0.386	0.116	0.041	-0.058	0.299	0.494
LIQUIDITY	0.403	0.439	0.531	0.597	0.193	0.187
ΔTRADING	0.035	-0.062	0.035	-0.038	-0.071	-0.075
FOREIGN LISTING	0.403	0.670	0.749	0.892	0.020	-0.013
ΔLT FINANCE	0.069	-0.048	0.063	0.071	0.197	0.119
OUTSOURCING	-0.382	-0.183	-0.176	-0.086	-0.186	-0.207
HORIZONTAL	-0.245	-0.271	-0.249	-0.189	-0.154	-0.132
VERTICAL	-0.242	-0.285	-0.320	-0.215	0.079	-0.099
FULL INTEGRATION	0.443	0.160	0.094	-0.094	0.253	0.477
EFF(CRS)	0.266	0.167	0.347	0.313	0.358	0.333
EFF(VRS)	0.162	0.157	0.304	0.313	0.289	0.250

Table A.3: Correlation matrix for first and second stage variables

A.4 Robustness Checks

	Regressions without financial flexibility and business model variables							
A.4.1	Constant Returns-To-Scale				Variable Returns-To-Scale			
	(2) EFF	(3) MQ	(4) ΔEFF	(5) ΔTECH	(6) EFF	(7) MQ	(8) ΔEFF	(9) ΔTECH
DEMUT	0.123***	0.056	-0.132*	0.212***	0.168***	-0.041*	-0.095***	0.057*
Std. Err.	*0.046*	*0.067*	*0.073*	*0.091*	*0.059*	*0.024*	*0.015*	*0.035*
LISTED	-0.005	-0.047	-0.166	0.103***	-0.003	0.005	-0.139	0.156**
Std. Err.	*0.060*	*0.167*	*0.149*	*0.028*	*0.072*	*0.161*	*0.114*	*0.073*
LIQUIDITY	0.006	-0.001	0.033	-0.051*	0.115***	0.016	0.086*	-0.056
Std. Err.	*0.030*	*0.028*	*0.031*	*0.031*	*0.038*	*0.055*	*0.051*	*0.087*
ΔTRADING	-0.010	0.032	-0.019	0.057	-0.012	0.082**	0.027	0.069
Std. Err.	*0.037*	*0.037*	*0.051*	*0.058*	*0.047*	*0.034*	*0.073*	*0.069*
FOREIGN LISTING	1.851***	0.766†	-0.814	1.795*	3.161	-0.526	-0.348	-0.196
Std. Err.	*0.384*	*0.544*	*0.855*	*0.980*	-	*0.795*	*0.470*	*0.996*
EFF		-1.147***	-0.979***	-0.178		-0.623**	-0.981***	0.281***
Std. Err.		*0.307*	*0.334*	*0.139*		*0.274*	*0.311*	*0.113*
CONST	0.564***	1.735***	1.707***	1.058***	0.533	1.513***	1.748***	0.835***
Std. Err.	*0.038*	*0.208*	*0.212*	*0.071*	-	*0.211*	*0.222*	*0.080*

	Regressions without competition variables							
A.4.2	Constant Returns-To-Scale				Variable Returns-To-Scale			
	(2) EFF	(3) MQ	(4) ΔEFF	(5) ΔTECH	(6) EFF	(7) MQ	(8) ΔEFF	(9) ΔTECH
DEMUT	0.103	-0.029	-0.135***	0.123**	0.136*	-0.087***	-0.101***	0.012
Std. Err.	*0.100*	*0.042*	*0.021*	*0.057*	*0.084*	*0.025*	*0.031*	*0.023*
LISTED	0.095	-0.008	-0.080	0.048	0.062	0.055	-0.064	0.126*
Std. Err.	*0.096*	*0.105*	*0.097*	*0.045*	*0.093*	*0.106*	*0.094*	*0.068*
ΔLT FINANCE	-0.003	-0.035	0.029	-0.089***	-0.033	-0.019	0.055	-0.086
Std. Err.	*0.035*	*0.068*	*0.066*	*0.032*	*0.044*	*0.073*	*0.054*	*0.063*
OUTSOURCING	0.087	-0.340***	-0.484***	0.172***	0.033	-0.419***	-0.455***	0.073
Std. Err.	-	*0.047*	*0.037*	*0.064*	-	*0.109*	*0.069*	*0.057*
HORIZONTAL	-0.094	-0.142***	-0.263***	0.171	-0.167*	-0.112***	-0.124***	0.020
Std. Err.	*0.111*	*0.057*	*0.108*	*0.133*	*0.094*	*0.044*	*0.051*	*0.054*
VERTICAL	-0.071	-0.204	-0.314***	0.162	0.006	-0.065	-0.163***	0.087
Std. Err.	*0.078*	*0.170*	*0.105*	*0.145*	*0.095*	*0.141*	*0.050*	*0.143*
FULL INTEGRATION	-0.160	0.043	-0.161***	0.209†	-0.237**	0.182***	-0.041	0.209*
Std. Err.	*0.136*	*0.091*	*0.058*	*0.144*	*0.116*	*0.067*	*0.062*	*0.113*
EFF		-1.039***	-1.038***	0.005		-0.648***	-1.033***	0.314*
Std. Err.		*0.300*	*0.303*	*0.054*		*0.22*	*0.317*	*0.165*
CONST	0.668***	1.892***	2.035***	0.843***	0.857***	1.647***	2.026***	0.699***
Std. Err.	*0.087*	*0.184*	*0.148*	*0.055*	*0.097*	*0.128*	*0.234*	*0.159*

Table A.4: Robustness check by omitting variables

	Regressions with different competition variables							
A.5.1	Constant Returns-To-Scale				Variable Returns-To-Scale			
ΔTRADING$_{t-1}$ for t	(2) EFF	(3) MQ	(4) ΔEFF	(5) ΔTECH	(6) EFF	(7) MQ	(8) ΔEFF	(9) ΔTECH
DEMUT	0.111*	-0.004	-0.157***	0.171**	0.107*	-0.085**	-0.095***	0.006
Std. Err.	*0.060*	*0.041*	*0.037*	*0.072*	*0.057*	*0.038*	*0.033*	*0.028*
LISTED	0.015	0.010	-0.077	0.079**	0.049	0.038	-0.107	0.152**
Std. Err.	-	*0.112*	*0.087*	*0.036*	*0.069*	*0.125*	*0.100*	*0.070*
LIQUIDITY	-0.034	-0.041***	0.011	-0.074*	0.064†	-0.03	0.076*	$-0.099^{\dagger}$
Std. Err.	*0.024*	*0.016*	*0.035*	*0.041*	*0.044*	*0.039*	*0.043*	*0.066*
ΔTRADING	0.020*	0.022	0.015	0.035	0.046	-0.034	-0.078*	0.045
Std. Err.	*0.010*	*0.042*	*0.042*	*0.039*	*0.041*	*0.037*	*0.046*	*0.030*
FOREIGN LISTING	1.154***	0.872†	-0.643	1.687*	3.120***	-0.184	-0.041	-0.166**
Std. Err.	*0.407*	*0.552*	*0.853*	*0.956*	*0.642*	*0.842*	*0.429*	*0.937*
ΔLT FINANCE	0.009	-0.025	0.026	-0.070***	-0.001	-0.025	0.044	-0.081
Std. Err.	*0.031*	*0.062*	*0.076*	*0.024*	*0.040*	*0.077*	*0.047*	*0.040*
OUTSOURCING	0.109	-0.345***	-0.479***	0.162***	0.156***	-0.421***	-0.457***	0.074
Std. Err.	-	*0.050*	*0.041*	*0.052*	*0.062*	*0.11*	*0.057*	*0.063*
HORIZONTAL	-0.017	-0.129***	-0.244**	0.189	-0.140**	-0.149***	-0.192***	0.052
Std. Err.	*0.037*	*0.022*	*0.123*	*0.185*	*0.072*	*0.05*	*0.046*	*0.071*
VERTICAL	-0.008	-0.206	-0.307***	0.158	0.098	-0.081	-0.174***	0.083
Std. Err.	*0.045*	*0.15*	*0.122*	*0.124*	*0.082*	*0.121*	*0.053*	*0.122*
FULL INTEGRATION	-0.088	0.052	-0.146*	0.222	-0.146*	0.152*	-0.100	0.239*
Std. Err.	-	*0.095*	*0.088*	*0.180*	*0.083*	*0.09*	*0.080*	*0.128*
EFF		-1.104***	-1.000***	-0.119		-0.624***	-1.008***	0.313**
Std. Err.		*0.311*	*0.351*	*0.125*		*0.239*	*0.307*	*0.148*
CONST	0.578	1.923***	2.019***	0.902***	0.718***	1.684***	1.985***	0.772***
Std. Err.	-	*0.18*	*0.152*	*0.038*	*0.085*	*0.137*	*0.201*	*0.122*

A.5.2	Constant Returns-To-Scale				Variable Returns-To-Scale			
ΔLIQUIDITY for ΔTRADING	(2) EFF	(3) MQ	(4) ΔEFF	(5) ΔTECH	(6) EFF	(7) MQ	(8) ΔEFF	(9) ΔTECH
DEMUT	0.129***	-0.002	-0.156***	0.177**	0.172**	-0.090**	-0.108***	0.015
Std. Err.	*0.048*	*0.044*	*0.042*	*0.076*	*0.078*	*0.038*	*0.037*	*0.030*
LISTED	0.039	0.005	-0.079	0.059†	0.021	0.058	-0.070	0.134**
Std. Err.	*0.073*	*0.107*	*0.088*	*0.040*	*0.085*	*0.114*	*0.094*	*0.061*
LIQUIDITY	0.009	-0.084**	-0.026	-0.049	0.048	-0.065	0.076**	-0.128**
Std. Err.	*0.031*	*0.041*	*0.037*	*0.035*	*0.047*	*0.055*	*0.039*	*0.067*
D LIQUIDITY	-0.021	-0.069**	-0.058	0.024	-0.018	-0.037	0.025	-0.057***
Std. Err.	*0.037*	*0.035*	*0.044*	*0.030*	*0.051*	*0.032*	*0.021*	*0.017*
FOREIGN LISTING	1.796***	1.060*	-0.489	1.655*	3.107***	-0.094	-0.184	0.049
Std. Err.	*0.383*	*0.567*	*0.803*	*0.94*	*0.663*	*0.939*	*0.433*	*1.021*
DELTA LT FINANCE	-0.007	-0.030	0.022	-0.074***	-0.013	-0.020	0.054	$-0.086^{\dagger}$
Std. Err.	*0.033*	*0.067*	*0.077*	*0.021*	*0.041*	*0.071*	*0.053*	*0.055*
OUTSOURCING	0.047	-0.362***	-0.493***	0.165***	0.158**	-0.427***	-0.446***	0.058
Std. Err.	*0.061*	*0.038*	*0.043*	*0.062*	*0.077*	*0.121*	*0.076*	*0.059*
HORIZONTAL	-0.044	-0.149***	-0.257**	0.155	-0.105	-0.115***	-0.116**	0.010
Std. Err.	0.071	0.062	0.120	0.148	0.083	0.044	0.055	0.056
VERTICAL	-0.006	-0.222	-0.320***	0.153	0.071	-0.079	-0.148***	0.06
Std. Err.	*0.084*	*0.166*	*0.132*	*0.119*	*0.09*	*0.126*	*0.057*	*0.116*
FULL INTEGRATION	-0.100	0.047	-0.148**	0.192	-0.165*	0.183***	-0.041	0.210*
Std. Err.	*0.086*	*0.103*	*0.073*	*0.159*	*0.089*	*0.073*	*0.067*	*0.121*
EFF		-1.079***	-0.981***	-0.114		-0.643***	-1.027***	0.315**
Std. Err.		*0.329*	*0.355*	*0.119*		*0.246*	*0.314*	*0.150*
CONST	0.595***	1.957***	2.048***	0.895***	0.701***	1.710***	1.958***	0.820***
Std. Err.	*0.081*	*0.157*	*0.134*	*0.032*	*0.092*	*0.144*	*0.224*	*0.114*

Table A.5: Robustness check with varying competition variables

	Regressions with Bootstrapping (2000 Replications, 5%, 10%, and 15%-Levels)							
A.6	Constant Returns-To-Scale				Variable Returns-To-Scale			
Bootstrapping	(2) EFF	(3) MQ	(4) ΔEFF	(5) ΔTECH	(6) EFF	(7) MQ	(8) ΔEFF	(9) ΔTECH
DEMUT	0.133*	0.001	-0.161*	0.187**	0.191**	$-0.086^{\dagger}$	-0.107	0.025
Std. Err.	*0.097*	*0.106*	*0.098*	*0.047*	*0.133*	*0.091*	*0.097*	*0.055*
LISTED	0.040	-0.001	-0.083	0.060	0.091	0.054	-0.068	0.127*
Std. Err.	*0.150*	*0.159*	*0.129*	*0.062*	*0.201*	*0.160*	*0.124*	*0.079*
LIQUIDITY	0.006	-0.032	-0.002	-0.040	-0.034	-0.021	0.059	-0.063
Std. Err.	*0.065*	*0.105*	*0.106*	*0.080*	*0.094*	*0.059*	*0.092*	*0.089*
ΔTRADING	-0.002	0.008	-0.037	0.060	0.083**	0.040	0.003	0.059
Std. Err.	*0.049*	*0.066*	*0.066*	*0.059*	*0.060*	*0.057*	*0.091*	*0.074*
FOREIGN LISTING	1.803**	0.874	-0.566	1.609**	2.347*	-0.271	-0.109	-0.218
Std. Err.	*0.914*	*0.926*	*0.873*	*0.906*	*1.336*	*0.880*	*0.983*	*0.896*
ΔLT FINANCE	-0.045	-0.029	0.029	-0.084	-0.007	-0.026	0.054	-0.095*
Std. Err.	*0.037*	*0.123*	*0.091*	*0.060*	*0.067*	*0.076*	*0.061*	*0.059*
OUTSOURCING	0.045	-0.343**	-0.498**	0.187	-0.010	-0.400*	-0.450**	0.099
Std. Err.	*0.097*	*0.240*	*0.190*	*0.145*	*0.158*	*0.282*	*0.228*	*0.138*
HORIZONTAL	-0.039	-0.214**	-0.300*	0.132	0.150*	-0.085	-0.154	0.053
Std. Err.	*0.129*	*0.160*	*0.145*	*0.160*	*0.191*	*0.140*	*0.221*	*0.199*
VERTICAL	-0.006	-0.153	-0.247	0.137	0.180	-0.128	-0.116	-0.010
Std. Err.	*0.208*	*0.294*	*0.211*	*0.162*	*0.408*	*0.300*	*0.238*	*0.167*
FULL INTEGRATION	-0.101	0.029	-0.127	0.147	0.164	0.145	-0.041	0.153
Std. Err.	*0.173*	*0.217*	*0.163*	*0.165*	*0.232*	*0.194*	*0.224*	*0.206*
EFF		-1.096**	-1.002**	-0.096		-0.634**	-1.033**	0.329**
Std. Err.		*0.224*	*0.192*	*0.113*		*0.193*	*0.165*	*0.168*
CONST	0.592**	1.923**	2.032**	0.888**	0.654**	1.674**	1.977**	0.766**
Std. Err.	*0.111*	*0.219*	*0.182*	*0.149*	*0.170*	*0.197*	*0.189*	*0.179*

Table A.6: Bootstrap test

Appendix B

Chapter 4

B.1 Discriminatory offers by for-profit exchanges

In the analysis so far, we only allowed for identical offers made by X_2 to the members of the mutual exchange. Let us now assume that the outsider-owned exchange might use discriminatory offers. In this case, an outsider-owned exchange will pursue a divide-and-conquer strategy.[1], which means that the exchange makes a sweet offer to a fraction x of randomly chosen customers of X_1 such that these customers will transfer their new volume to X_2. The remaining $1-x$ do not get this special offer, however they can observe the offer made to the others. Hence, they know that they would have to bear a higher unit fixed cost by staying loyal in the case that X_1 invests and will therefore be individually induced to leave the mutual exchange, which results in a *snowballing* effect.

Thus, X_2 will offer the following trading fee structure to the customers of X_1: The portion x of targeted customers obtain an offer of (or slightly below) $\hat{a} \equiv c-(\theta-\frac{I}{v+k})$. As a result, they will transfer their new volume, since they cannot get a better offer at X_1, even if all members stayed loyal. Furthermore, the outsider-owned exchange will offer the remaining $1-x$ customers a_2 such that

$$a_2(x) \equiv c-(\theta-\frac{I}{v+(1-x)k}). \tag{B.1}$$

Note that the outsider-owned exchange obtains larger rents from charging the fraction x of customers a trading fee $\hat{a}$ and the remaining customers $1-x$ a fee of $a_2(x) > \hat{a}$, than charging all customers $\hat{a}$. By applying such a divide-and-conquer strategy, the outsider-owned exchange dilutes the customer base of the mutual exchange without offering the defecting customers significantly better conditions from an expected value viewpoint. This strategy will be successful as X_2 knows that a shrinking customer base at X_1 results in higher trading fees for its customers who stay loyal with their new volume, if X_1 decides to invest. This will lower the value of the investment for the mutual stock exchange and reduces its incentive to decide for it at period 0. As a consequence, the second-sourcing effect discovered in the last section loses its relevance in this scenario. Hence, the mutual exchange will have a lower propensity to invest in the project than before.

To show this, we derive the optimal strategy of the for-profit exchange. X_2 offers the customers of X_1 with $x \in [0,1]$ a continuum of offers $a_2(x)$ such that

$$a_2(x) \equiv c-(\theta-\frac{I}{v+(1-x)k}) \qquad \text{for all } x. \tag{B.2}$$

At the boundaries of x, this translates into the offers $a_2(0)=\hat{a}$ and $a_2(1)=\bar{a}\equiv c-(\theta-\frac{I}{v})$. Note that by using such a strategy, the outsider-owned exchange essentially offers the first member of the continuum the same conditions (or slightly below) she could expect if all other members stayed loyal to the mutual exchange. Since this customer will accept the offer, the second gets an offer that is a little bit worse, and so on. The last customer merely obtains $\bar{a}$, which is equivalent to what it could expect as unit costs if she was the only remaining member who trades her transferable volume at X_1. Applying this strategy also deters coordination by the members, since everyone runs to be the first in line, thereby getting the best offer from the investor-owned exchange. Essentially, the outsider-owned exchange induces a run amongst the members of the mutual exchange.

Therefore, it is interesting to analyze the parameter values at which the mutual exchange will decide to invest in period 0, taking into account the outlined strategic move by X_2. Since customers will be treated heterogeneously by such a policy, we have to formulate the condition

[1] For a general analysis of these strategies, see for instance Segal (2003).

in expected value terms. A representative member can expect a fee of

$$E[a_2(x)] = \check{a} \equiv c - (\theta - \frac{I}{v + \frac{k}{2}}). \tag{B.3}$$

If the mutual exchange does *not* invest, all members can expect to get conditions such that they are indifferent between changing their volume to exchange X_2 and staying at their home exchange X_1. It follows that they can expect trading costs of $c(v + k)$. However, if the mutual exchange decides to invest into the project, the members can expect trading costs to be at

$$(c - (\theta - \frac{I}{v}))v + \check{a}k \tag{B.4}$$

From inserting $\check{a} = c - (\theta - \frac{I}{v+\frac{k}{2}})$ into condition (B.4) we obtain the following condition for investing by a mutual after rearranging:

$$I \leq \frac{(2v + k)(v + k)}{2v + 3k}. \tag{B.5}$$

Only if the investment costs are lower than depicted in condition B.5, a mutual exchange operating in the interest of its member will invest into the project. In order to compare this result with the investment cost hurdle of nondiscriminating offers, we obtain:

$$\frac{(2v + k)(v + k)}{2v + 3k} \lesseqqgtr \frac{\theta(v + k)^2}{v + 2k}. \tag{B.6}$$

We find that the range of investment costs such that the mutual exchange will invest into the project is *lower* if the investor-owned exchange uses the above formulated divide-and-conquer strategy. In fact,

$$\frac{(2v + k)(v + k)}{2v + 3k} < \frac{\theta(v + k)^2}{v + 2k} \Leftrightarrow 0 < k(2v + k), \tag{B.7}$$

which holds, since $v, k > 0$ by assumption. Hence, the mutual exchange has a lower propensity to invest, even though we still observe the "second-sourcing" effect that makes the investment attractive by increasing the bargaining power of its members.

B.2 Multiplicity of Equilibria

Coordination games like the one analyzed in this paper are typically afflicted with the problem of multiple equilibria, where significantly different efficiency outcomes may occur. The global games framework, which we employed, provides a mitigation to this problem. To illustrate that in our analysis, let us consider a situation where the outsider-owned exchange can only make *nondiscriminatory* offers. In the equilibrium we analyzed in section 4.2.2, the condition on trading costs such that the volume will be transferred to the outsider-owned exchange is

$$a_2 \leq \hat{a} = c - (\bar{\theta} - \frac{I}{v + k}).$$

where $\theta = \bar{\theta}$ is a certain level of efficiency gain. Our analysis implied that each member expects the other members of the mutual exchange to stay until a dominating offer arrives for all of them. This forces the outsider-owned exchange to deliver an offer which is at least as good for the user as the best possible offer of the mutual exchange. Thus in a certain sense, members have bargaining power when they can coordinate their actions and this is anticipated by the outsider-owned exchange. But given a different structure of beliefs by the members, other equilibria are also possible. For instance, if each member believes that the other members will move their new volume as soon as

$$a_2 \leq \bar{a} = c - (\bar{\theta} - \frac{I}{v}),$$

then it is also individually rational to move the new volume if such an offer will be made by the outsider-owned exchange. But, because of $\bar{a} > \hat{a}$ the latter offer is not very attractive for the members of the mutual exchange in total. Hence, we have multiple equilibria with the payoff for each member depending on the equilibrium on which they coordinate. Thus, the outsider-owned exchange is in a situation of strategic uncertainty, since it does not know how the members will react to a given offer. To be on the safe side, it would offer $\hat{a}$ to attract all members with certainty. However, in case it overestimated the coordination abilities of the members, this would be a too costly deal viewed from the perspective of the outside owners whose interests X_2 has to maximize. Therefore, we analyze the circumstances under which the outsider-owned exchange can afford to make an offer which is strictly lower than $\hat{a}$, but nevertheless attracts the total transferable volume k of the mutual's members.

To deal with this issue we draw on the *global games* approach to find an unique equilibrium. The global games approach builds on the idea that individual players, in our case the members of the exchange, are facing payoff uncertainty which is caused by an underlying state of the economy. In our framework, this would correspond to uncertainty regarding the productivity parameter of the investment technology θ. We assume that for each exchange X_i, θ_i is *independently* drawn from the same smooth distribution $F(\theta)$ on the real line with an expected value $E[\theta]$. Furthermore, we assume that the density function $f(\theta)$ is unimodal with *nearly all* its mass lying on the expected value $E[\theta]$. Each member i of the mutual exchange X_1 receives an individual signal $s_{1,i}$ concerning the project's productivity at its own exchange θ_1, which is distributed *uniformly* on the interval $[\theta_1 - \epsilon, \theta_1 + \epsilon]$ such that for two distinct members $i \neq j$, $s_{1,i}$ is independent of $s_{1,j}$. Regarding the productivity of the outsider-owned exchange, let us assume that all its potential users as well as its outside owners, in whose interests the exchange acts, merely know that this exchange will have an expected productivity gain of $E[\theta]$. Likewise, the outside owners of the for-profit exchange (and its management) also merely know the expected productivity of the investment of the mutual exchange. Hence, we assume that the management of the outsider-owned exchange neither knows the future realization of the productivity state θ_2 of its own exchange nor the productivity state of the mutual exchange θ_1 at the time, at which it has to make its offer a_2 to the members of X_1.[2] Therefore, its offer is based on the expected productivity gain $E[\theta]$. Note that this information structure is in line with our assumption on the time structure and credibility of the offers made by the two exchanges. Since X_2 will move first to make its offer due to its higher commitment to the offer, it is plausible to assume that the members who individually decide over accepting this offer, act later on a better information basis.

For the members of the mutual exchange the payoffs of the game are determined by the underlying state variable θ_1, given the cumulative probability distribution $F(\theta)$. The signal they receive regarding the state variable θ_1 tells them about the payoffs of other members and, crucially, also about the signals that other members are likely to have received. Thus, they

[2] We think that these assumptions on the information structure are quite realistic. Mutual exchanges are owned by its main users who have typically a better information base than outside owners of a for-profit exchange whose only interest is financially motivated and who often lack deeper stock industry knowledge. In addition, it seems plausible that given our time structure the management of the outside-owned exchange at the time it has to announce its offer not yet knows the state of the world.

possess not only different beliefs, but also different beliefs about the other members' beliefs, and so on. As we will see, this belief structure will determine how they will act in equilibrium.

To understand why this is the case, let us consider an example with just two members $m_i, i = 1, 2$, each with transferable trade volume $k/2$ so that the total adds to k. In essence, both members are playing a coordination game with the following payoffs: The payoff that each

	Stay	Withdraw
Stay	$\hat{a}(\theta_1), \hat{a}(\theta_1)$	$\tilde{a}(\theta_1), a_2$
Withdraw	$a_2, \tilde{a}(\theta_1)$	a_2, a_2

Table B.1: Payoff Structure with Two Members

member receives, if they both trade its volume $k/2$ at the mutual exchange is equal to

$$\hat{a}(\theta_1) = c - (\theta_1 - \frac{I}{v+k}). \tag{B.8}$$

If both members accept the offer of the outsider-owned exchange, they each have trading costs of a_2 per unit. However, if only one of the member accepts the offer, the remaining member has trading costs of

$$\tilde{a}(\theta_1) \equiv c - (\theta_1 - \frac{I}{v+\frac{k}{2}}). \tag{B.9}$$

Hence, $\tilde{a}(\theta_1)$ is clearly higher than $\hat{a}(\theta_1)$. Note that the type of coordination game played depends on the offer a_2 made by X_2, which is a *strategic* variable for this exchange. To examine how the offer by X_2 will be set, we need to analyze two scenarios: The first scenario, as we will see, has an unique equilibrium where both members withdraw if and only if

$$a_2 < \frac{1}{2}(\hat{a}(\theta_1) + \tilde{a}(\theta_1)). \tag{B.10}$$

The same logic can be used to show that both members are staying with its transferable volume at the mutual exchange if and only if

$$a_2 \geq \frac{1}{2}(\hat{a}(\theta_1) + \tilde{a}(\theta_1)), \tag{B.11}$$

which is our second scenario. To conclude the argument, we have to show that given our assumption on the distribution function of θ, the outsider-owned exchange's optimal choice is an offer a_2 where the trading costs are (slightly lower than) $(\hat{a}(\theta_1) + \tilde{a}(\theta_1))/2$, thereby inducing all the members to transfer its volume to the outsider-owned exchange.

From our assumption regarding the information on the state variable θ_1 which the two members of the mutual exchange X_1 receive, we know that they are highly correlated. Each member will therefore expect trading costs of $\hat{a}(s_{1,i}(\theta_1))$ in case the other member also stays with its volume at X_1, and $\tilde{a}(s_{1,i}(\theta_1))$ if it expects the other member to divert its volume. When observing a certain offer of a_2, which will be derived later on, both members i know that staying with their volume is the best choice for them if both get a signal $s_{1,i}$ concerning the trading costs of its mutual exchange such that

$$\hat{a}(s_{1,i}(\theta_1)) + 2\epsilon < a_2 \qquad \text{for } i = 1, 2. \tag{B.12}$$

When both members get such a high signal on the productivity of the investment at their own exchange, they also know that the other's signal will be high enough to prefer to stay at the mutual exchange. This happens because both members know that the other's signal is within

2ϵ of their own signal. For a numerical example, let us normalize the trading offer of the outsider-owned exchange with $a_2 = 1$ and suppose $\epsilon = 0.05$. In this case, if member 1 gets a signal that results in trading costs of $\hat{a}(s_{1,1}) = 0.95$ it can deduce that the true state θ_1 must result in trading costs in the range $0.9 - 1$ and hence that the signal which member 2 gets can only lie in a range that infers trading costs of $0.85 - 1.05$. Only if the signal-related trading cost of member 1 lies at $\hat{a}(s_{1,1}) < 0.9$, it knows that member 2 will also get a signal that induces its to prefer to trade its total volume at the mutual exchange, given the offer $a_2 = 1$ of the outsider-owned exchange. Therefore, if both members get a signal which results in trading costs $\hat{a}(s_{1,i}) < 0.9 = 1 - 2\epsilon$ both members know that they prefer to trade at their exchange X_1.

Going one step further, when do both members know that both members know that both signals are such that both members prefer to trade at its mutual exchange? Hence, we are talking about the *second order* beliefs of the members. By the same argument as given above one can show that only if both signals are such that, given the signal, the trading costs are $\hat{a}(s_{1,i}) < 0.8 = 1 - 4\epsilon$, these second order beliefs will be satisfied. To see this, suppose that member 1 gets a signal indicating its trading costs would be 0.85, given the signal. Member 1 deduces that the true trading costs must lie between 0.8 and 0.9, and hence member 2's signal makes its infer that the trading costs are between 0.75 and 0.95. However, member 1 also has to think about what member 2 would deduce about the signal that member 1 had received. Since member 1 knows that member 2 could have received a signal which produces trading costs of 0.95 it also knows that such a member 2-type would result in a positive probability that the signal of member 1 is in the range $0.85 - 1.05$ as above. Only with signals which lead to trading costs lower than $1 - 4\epsilon = 0.8$, such second order beliefs are excluded and both members know that both members know that both prefer trading at their home exchange.

As we increase the number of order of beliefs, the range of θ_1 will rise. Thus, even with very high productivity parameters θ_1, it can never be *common knowledge* that both members will stay with their volumes at the mutual exchange.

What follows from these higher order beliefs in general? One should analyze the consequences when ϵ is very small. The reason is that such a structure presumes small differences of information among members and therefore can be considered as a relatively minor departure from the basic framework depicted in section 4.2.1. Since θ is smoothly distributed, this implies that the probability of the signal $s_{1,j}$ of the member j being above or below the signal $s_{1,i}$ of member i for$i \neq j$ approaches 0.5 in each case as $\epsilon \to 0$. Thus, we will take it as 0.5 in following.

How do the members behave in equilibrium? The most natural strategy for each member would be a *switching* strategy, where they only stay with their volume at X_1 if their signal $s_{1,i}$ is at least as large as some threshold value l, and withdraw their additional volume otherwise. Let us suppose that member 1 follows this strategy and member 2 gets a signal $s_{1,2} = l$. What does member 2 infer from the signal that member 1 got? Given that ϵ is very small and θ_1 is drawn from a smooth distribution, member 2 deduces a probability of 0.5 that $s_{1,1} < l$ and that member 1 will withdraw its transferable volume and with a probability of 0.5 that $s_{1,1} \geq l$ and that member 1 will stay with its volume at the mutual exchange, according to the presumed switching strategy. Hence, the trading cost of member 2 from *staying* is

$$0.5\hat{a} + 0.5\tilde{a} = 0.5(c - (\theta_1 - \frac{I}{v+k}) + c - (\theta_1 - \frac{I}{v+\frac{k}{2}})) = c - (\theta_1 - \frac{I}{v+\frac{3k}{4}}), \tag{B.13}$$

and the trading costs from withdrawing is

$$0.5a_2 + 0.5a_2 = a_2. \tag{B.14}$$

Therefore, member 2 will withdraw if

$$a_2 < c - (\theta_1 - \frac{I}{v + \frac{3k}{4}}). \tag{B.15}$$

If condition (B.15) is satisfied, then member 2 will withdraw. In fact, it will withdraw even when its signal $s_{1,2} = l$ is higher than l, but lower than some cutoff point l^*, where it is indifferent between staying and withdrawing in terms of expected trading costs. However, now again we have an infection argument of the kind described above going on. Since both members are in symmetric positions, using the same argument one can show that member 1 will have a cutoff point higher than l^*. That is a contradiction with the initial assumption that member 1 will remain at the mutual exchange and therefore both members staying with its volume at the mutual exchange cannot be an equilibrium. Instead, both members will always withdraw in equilibrium, if condition (B.15) is satisfied, and for small values of ϵ this equilibrium is indeed unique.[3]

Hence, we have shown that withdrawing is the only remaining equilibrium if the outsider-owned exchange makes an offer a_2 to both members similar to the one depicted in condition (B.15). Note that the payoff of retaining the volume at the mutual exchange depends on θ_1, which we have assumed to be a random variable. However, given our assumption that the density function of θ has nearly all its mass on its mean $E[\theta]$, the outsider-owned exchange can expect that θ_1 will be close to this parameter. Substituting $E[\theta]$ for θ_1 in condition (B.15) gives us a condition for an optimal offer of the outsider-owned exchange such that the outsider-owned exchange can expect that members of the mutual exchange to withdraw their volume. As can be seen from equation (B.13), this optimal offer corresponds to condition (B.10) given above. In consequence, the outsider-owned exchange will succeed in destabilizing the mutual. Note also that the resulting equilibrium is the *risk-dominant* equilibrium which always implies some coordination failure among the members.

Generalizing to the case with a continuum of traders we can focus on the risk-dominant equilibrium which is the unique equilibrium when the perception of a small payoff uncertainty exists, as shown by the global games approach. Hence, given this equilibrium the outsider-owned exchange X_2 will set the offer $a_2 < \check{a}$ such that the trading costs are slightly lower than

$$\check{a} \equiv c - (\theta - \frac{I}{v + \frac{k}{2}}). \tag{B.16}$$

The condition corresponds to the one given in section 4.2.2.1.

[3]The argument used to eliminate an equilibrium depends on members using a switching strategy, where below some signal level, the members withdraw and above some level they stay with their volume at the mutual exchange. Naturally, there also exist other strategies. However, Morris and Shin (2003) show that switching strategies are optimal in the global games approach.

B.3 Stock exchanges employed in regressions

No.	Exchange	Governance			Related Activities		
		Mutual/State	Demutualized	Listed	Post-Trading	Derivatives	Software
1	Australian	-	1998-	1998-	$\surd$	$\surd$	-
2	BOVESPA	$\surd$	-	-	-	$\surd$	-
3	Budapest	-	2002-	-	-	$\surd$	-
4	Copenhagen	-	1996-	-	2000-	$\surd$	-
5	Deutsche Börse	-	2000-	2001-	2000-	$\surd$	$\surd$
6	Euronext†	-	2000-	2001-	$\surd$	$\surd$	$\surd$
7	Hellenic*	-	1995-	2000-	2000-	2002-	2000-
8	Hongkong	-	2000-	2000-	$\surd$	$\surd$	-
9	Istanbul	$\surd$	-	-	-	2001-	-
10	Jakarta	$\surd$	-	-	$\surd$	-	-
11	Johannesburg JSE	$\surd$	-	-	$\surd$	2001-	-
12	Kuala Lumpur	$\surd$	-	-	$\surd$	$\surd$	-
13	Lima	-	2003-	-	-	2003-	-
14	London	-	2000-	2001-	-	2003-	-
15	NASDAQ	-	2001-	-	-	-	-
16	NYSE	$\surd$	-	-	-	-	-
17	OMX	-	1993-	1998-	2001-	$\surd$	$\surd$
18	Oslo	-	2001-	-	-	$\surd$	-
19	Philippine	-	2001-	-	2003-	-	-
20	Singapore SGX†	-	1999-	2000-	$\surd$	$\surd$	2000-
21	SWX Zurich	-	2002-	-	-	$\surd$	-
22	Taiwan	$\surd$	-	-	$\surd$	-	-
23	Thailand	$\surd$	-	-	$\surd$	-	-
24	Tokyo	-	2001-	-	$\surd$	$\surd$	2002-
25	Toronto TSX	-	2000-	2002-	-	-1999	2002-
26	Vienna	-	1998-	-	2000-	$\surd$	-
	Total	9	17	9	17	20	7

*: Athens Stock Exchange in 1999
†: Pro forma figures for 1999
$\surd$: Exchange possessed this activity since 1999 or earlier

Table B.2: Exchanges Included in Probit Regressions (1999-2003)

B.4 Correlation Matrix

		(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**
(1)	**SETTLE**	1									
(2)	**DERIVAT**	0.144	1								
(3)	**SOFTWARE**	0.217	0.27	1							
(4)	**DEMUT**	0.081	0.294	0.408	1						
(5)	**LISTED**	0.268	0.235	0.548	0.566	1					
(6)	**BOARDCOMP**	0.037	0.105	-0.087	-0.33	-0.192	1				
(7)	**DELTRADEREV**	0.082	-0.033	-0.098	-0.07	-0.076	0.06	1			
(8)	**CMCONTROL**	-0.315	0.189	0.28	0.442	0.287	-0.179	-0.025	1		
(9)	**TRADECOST**	0.221	-0.311	-0.285	-0.285	-0.152	0.131	0.122	-0.517	1	
(10)	**SIZE**	-0.077	-0.147	0.216	-0.001	0.162	-0.224	-0.089	0.275	-0.539	1

Table B.3: Correlation of Employed Variables (1999-2003 Pooled)

B.5 Robustness Checks

	Univariate Probit Regressions (clustering)			
(1)	(2)	(3)	(4)	(5)
Related Business Activity:	**DEMUT**	**SETTLE**	**DERIV**	**SOFTWARE**
LISTED		**1.149*****	**0.893****	**1.719*****
Std. Err.		*0.415*	*0.396*	*0.505*
BOARDCOMP	**-2.600*****	**0.563**	**0.709**	**0.283**
Std. Err.	*0.910*	*0.942*	*0.907*	*0.857*
ΔTRADEREV	**-0.202**	**0.867**	**0.002**	**-0.317**
Std. Err.	*0.437*	*1.239*	*0.305*	*0.278*
CMCONTROL	**0.303*****	**-0.344*****	**-0.03**	**0.139**
Std. Err.	*0.113*	*0.121*	*0.138*	*0.213*
TRADECOST	**-0.024***	**0.011**	**-0.057*****	**-0.039***
Std. Err.	*0.013*	*0.013*	*0.015*	*0.023*
SIZE	**-0.268*****	**0.056**	**-0.375****	**0.004**
Std. Err.	*0.096*	0.111	0.16	*0.118*
CONST	**3.325***	**0.433**	**6.488*****	**-1.756**
Std. Err.	*1.808*	*2.104*	*2.392*	*2.823*
Observations	130	130	130	130
Wald $-\chi^2$	28.73	23.52	19.42	19.95

	Univariate Probit Regressions (Random Effects)			
(1)	(2)	(3)	(4)	(5)
Related Business Activity:	**DEMUT**	**SETTLE**	**DERIV**	**SOFTWARE**
LISTED		**1.325*****	**-0.347**	**7.853*****
Std. Err.		*0.384*	*0.925*	*3.200*
BOARDCOMP	**-4.105*****	**0.240**	**2.560†**	**-2.912†**
Std. Err.	*1.472*	*0.835*	*1.634*	*2.023*
ΔTRADEREV	**-0.275**	**0.424**	**-0.344**	**-1.533**
Std. Err.	*0.413*	*0.356*	*0.969*	*1.548*
CMCONTROL	**0.323****	**-0.299*****	**0.188**	**0.838†**
Std. Err.	*0.166*	*0.123*	*0.259*	*0.594*
TRADECOST	**-0.037****	**0.006**	**-0.127*****	**-0.155*****
Std. Err.	*0.019*	*0.012*	*0.040*	*0.057*
SIZE	**-0.428****	**0.014**	**-0.807*****	**1.244†**
Std. Err.	*0.184*	0.100	0.244	*0.822*
CONST	**6.401****	**1.185**	**12.282*****	**-23.021***
Std. Err.	*3.279*	*1.886*	*5.248*	*13.372*
Observations	130	130	130	130
Wald $-\chi^2$	14.94	15.78	16.57	8.63

	Univariate Logit Regressions (Random Effects)			
(1)	(2)	(3)	(4)	(5)
Related Business Activity:	**DEMUT**	**SETTLE**	**DERIV**	**SOFTWARE**
LISTED		**4.962*****	**1.124**	**7.390*****
Std. Err.		*1.565*	-	*2.751*
BOARDCOMP	**-7.274*****	**1.993**	**4.633**	**-4.447**
Std. Err.	*2.803*	*3.614*	-	*3.803*
ΔTRADEREV	**-0.476**	**-0.148**	**0.213**	**-2.155**
Std. Err.	*0.743*	*1.254*	*1.413*	*2.146*
CMCONTROL	**0.568***	**-1.309*****	**0.327**	**0.813**
Std. Err.	*0.304*	*0.521*	-	*0.953*
TRADECOST	**-0.065****	**-0.064**	**-0.186*****	**-0.269*****
Std. Err.	*0.034*	*0.047*	*0.064*	*0.101*
SIZE	**-0.777****	**-0.294**	**-1.891*****	**-0.006**
Std. Err.	*0.343*	0.285	0.556	0.559
CONST	**11.583***	**10.024***	**26.103*****	**-2.245**
Std. Err.	*6.302*	*6.057*	*8.833*	-
Observations	130	130	130	130
Wald $-\chi^2$	13.21	13.31	-	10.80

Table B.4: Univariate Regressions

B.6 Event Studies

This section describes the methodology used in figure 4.2. We first discuss the construction of the event study for the degree of diversification.

In a first step, we identified from our sample of 50 largest exchanges those that demutualized or went public in the five year time frame 1999-2003, and labeled them as 'Demutualized Group' (16 exchanges) and 'IPO Group' (7 exchanges), respectively. Thus, these exchanges were subject to the 'event' under consideration. We then identified those exchanges that remained mutuals during 1999 and 2003, which we denoted as 'Control Group' (25 exchanges). For each of the considered exchanges we counted the number of related activities they offered in each year. We then divided the sums by the amount of possible related activities in each year. Since we considered three related activities (derivatives, post-trading, software), each exchange was assigned a value of either zero (no related activities), 1/3, 2/3 or one (all three related activities) for each year. We then adjusted the fractions of the 'Demutualized Group' and 'IPO Group'-exchanges by deducting the 'Control Group's mean degree of diversification from it, for each year. This provided us an indication by how much the two groups' degree of diversification differs from that of the 'Control Group'. Then, we aligned the calculated values for the two groups according to the timing of the respective event. To be more specific, we rearranged the values for each of the exchanges of the 'Demutualized Group' and the 'IPO Group' in such a way that their values occurred at the same time, i.e. either prior (t-2, t-1), at (t), or after the event (t+1, t+2). Finally, we calculated the mean values of diversification for each of these time periods. The results for demutualization and IPO can be seen in tables B.5 and tables B.6, respectively.

In analogy to the procedure outlined above, conducted an event study that measured the change in revenue growth for the three groups of exchanges. In a first step, we again identified those exchanges that qualify for the event. In contrast to the approach above, we selected the exchanges from a smaller sample, as we do not have financial statement data for all of the 50 largest exchanges. This reduced our considered subsamples 'Demutualized Group', 'IPO Group' and 'Control Group' to 13, 7, and 13 exchanges, respectively. For the 'Demutualized Group' and 'IPO Group', we calculated the development in revenues by indexing them at the period in which the event occurred, i.e. the revenues of 2001 were used as base year, if the event took place in that year. For the exchanges of the control group we calculated these indices for several starting points separately, depending on the years an event had occurred in the 'Demutualized Group' and 'IPO Group'. To be more specific, we calculated the indices with the base years 1999, 2000, 2001 and 2002 in the event of demutualization as there occurred this event in these years. We the matched the exchanges from the 'Demutualized Group' and 'IPO Group' with the corresponding 'Control Group' tables and adjusted the revenue index as in analogy with the former event study. Then, as before, we aligned the calculated values for the 'Demutualized Group' and the 'IPO Group' according to the timing of the respective event and calculated mean values for each time period. The results can be seen in tables B.7 and tables B.8, respectively.

No.	Diversification - Demutualized Group	1999	2000	2001	2002	2003
1	Singapore (1999)	0.67	1.00	1.00	1.00	1.00
2	TSX (2000)	0.33	0.00	0.00	0.33	0.33
3	Deutsche Börse (2000)	0.67	1.00	1.00	1.00	1.00
4	Euronext (2000)	1.00	1.00	1.00	1.00	1.00
5	London (2000)	0.00	0.00	0.00	0.00	0.33
6	Hong Kong (2000)	0.67	0.67	0.67	0.67	0.67
7	Mexico Stock Exchange (2001)	0.00	0.00	0.00	0.00	0.00
8	Nasdaq (2001)	0.00	0.00	0.00	0.00	0.00
9	Oslo (2001)	0.33	0.33	0.33	0.33	0.33
10	Osaka (2001)	0.67	0.67	0.67	0.67	0.67
11	Philippine (2001)	0.00	0.00	0.00	0.00	0.33
12	Tokyo (2001)	0.67	0.67	0.67	1.00	1.00
13	Swiss Exchange (2002)	0.00	0.00	0.00	0.00	0.00
14	Spanish Exchanges (2002)	0.00	0.00	0.00	0.00	0.00
15	Budapest (2002)	0.33	0.33	0.33	0.33	0.33
16	Lima (2003)	0.00	0.00	0.00	0.00	0.33

No.	Diversification - Control Group	1999	2000	2001	2002	2003
1	Amex	0.33	0.33	0.33	0.33	0.33
2	Buenos Aires	0.67	0.67	0.67	0.67	0.67
3	Chicago Stock Exchange	0.00	0.00	0.00	0.00	0.00
4	Colombo	0.33	0.33	0.33	0.33	0.33
5	Irish	0.00	0.00	0.00	0.00	0.00
6	Istanbul	0.00	0.00	0.33	0.33	0.33
7	Jakarta	0.33	0.33	0.33	0.33	0.33
8	JSE South Africa	0.33	0.33	0.67	0.67	0.67
9	Korea	0.67	0.67	0.67	0.67	0.67
10	Kuala Lumpur	0.67	0.67	0.67	0.67	0.67
11	Ljubljana	0.00	0.00	0.00	0.00	0.00
12	Luxembourg	0.00	0.00	0.00	0.00	0.00
13	Malta	0.33	0.33	0.33	0.33	0.33
14	Mumbai	0.33	0.33	0.33	0.33	0.33
15	NYSE	0.00	0.00	0.00	0.00	0.00
16	Santiago	0.00	0.00	0.00	0.00	0.00
17	Sao Paulo	0.33	0.33	0.33	0.33	0.33
18	Shanghai	0.00	0.00	0.00	0.00	0.00
19	Shenzhen	0.33	0.33	0.33	0.33	0.33
20	Taiwan	0.33	0.33	0.33	0.33	0.33
21	Tehran	0.33	0.33	0.33	0.33	0.33
22	Tel-Aviv	0.67	0.67	0.67	0.67	0.67
23	Thailand	0.33	0.33	0.33	0.33	0.33
24	Warsaw	0.33	0.33	0.33	0.33	0.33
	Mean	0.28	0.28	0.31	0.31	0.31
	Median	0.33	0.33	0.33	0.33	0.33

No.	Control Group mean-adjusted	1999	2000	2001	2002	2003
1	Singapore	0.39	0.72	0.69	0.69	0.69
2	TSX	0.06	-0.28	-0.31	0.03	0.03
3	Deutsche Börse	0.39	0.72	0.69	0.69	0.69
4	Euronext	0.72	0.72	0.69	0.69	0.69
5	London	-0.28	-0.28	-0.31	-0.31	0.03
6	Hong Kong	0.39	0.39	0.36	0.36	0.36
7	Mexico Stock Exchange	-0.28	-0.28	-0.31	-0.31	-0.31
8	Nasdaq	-0.28	-0.28	-0.31	-0.31	-0.31
9	Oslo	0.06	0.06	0.03	0.03	0.03
10	Osaka	0.39	0.39	0.36	0.36	0.36
11	Philippine	-0.28	-0.28	-0.31	-0.31	0.03
12	Tokyo	0.39	0.39	0.36	0.69	0.69
13	Swiss Exchange	-0.28	-0.28	-0.31	-0.31	-0.31
14	Spanish Exchanges	-0.28	-0.28	-0.31	-0.31	-0.31
15	Budapest	0.06	0.06	0.03	0.03	0.03
16	Lima	-0.28	-0.28	-0.28	-0.28	0.06

No.	Event-adjusted (Demutualization)	t-2	t-1	t	t+1	t+2
1	Singapore			0.39	0.72	0.69
2	TSX		0.06	-0.28	-0.31	0.03
3	Deutsche Börse		0.39	0.72	0.69	0.69
4	Euronext		0.72	0.72	0.69	0.69
5	London		-0.28	-0.28	-0.31	-0.31
6	Hong Kong		0.39	0.39	0.36	0.36
7	Mexico Stock Exchange	-0.28	-0.28	-0.31	-0.31	-0.31
8	Nasdaq	-0.28	-0.28	-0.31	-0.31	-0.31
9	Oslo	0.06	0.06	0.03	0.03	0.03
10	Osaka	0.39	0.39	0.36	0.36	0.36
11	Philippine	-0.28	-0.28	-0.31	-0.31	0.03
12	Tokyo	0.39	0.39	0.36	0.69	0.69
13	Swiss Exchange	-0.28	-0.31	-0.31	-0.31	
14	Spanish Exchanges	-0.28	-0.31	-0.31	-0.31	
15	Budapest	0.06	0.03	0.03	0.03	
16	Lima	-0.28	-0.28	0.06		
	Median Demutualization	-0.28	0.03	0.03	0.03	0.19
	Mean Demutualization	-0.08	0.03	0.06	0.10	0.22

Table B.5: Diversification Data for Event Studies on Demutualization

No.	Diversification - IPO Group	1999	2000	2001	2002	2003
1	Hellenic Exchanges (2000)	0.00	0.67	0.67	1	1
2	Hong Kong (2000)	0.67	0.67	0.67	0.67	0.67
3	Singapore (2000)	0.67	1.00	1.00	1.00	1.00
4	Deutsche Börse (2001)	0.67	1.00	1.00	1.00	1.00
5	Euronext (2001)	1.00	1.00	1.00	1.00	1.00
6	London (2001)	0.00	0.00	0.00	0.00	0.33
7	TSX (2002)	0.33	0.00	0.00	0.33	0.33

No.	Diversification - Control Group	1999	2000	2001	2002	2003
1	Amex	0.33	0.33	0.33	0.33	0.33
2	Buenos Aires	0.67	0.67	0.67	0.67	0.67
3	Chicago Stock Exchange	0.00	0.00	0.00	0.00	0.00
4	Colombo	0.33	0.33	0.33	0.33	0.33
5	Irish	0.00	0.00	0.00	0.00	0.00
6	Istanbul	0.00	0.00	0.33	0.33	0.33
7	Jakarta	0.33	0.33	0.33	0.33	0.33
8	JSE South Africa	0.33	0.33	0.67	0.67	0.67
9	Korea	0.67	0.67	0.67	0.67	0.67
10	Kuala Lumpur	0.67	0.67	0.67	0.67	0.67
11	Ljubljana	0.00	0.00	0.00	0.00	0.00
12	Luxembourg	0.00	0.00	0.00	0.00	0.00
13	Malta	0.33	0.33	0.33	0.33	0.33
14	Mumbai	0.33	0.33	0.33	0.33	0.33
15	NYSE	0.00	0.00	0.00	0.00	0.00
16	Santiago	0.00	0.00	0.00	0.00	0.00
17	Sao Paulo	0.33	0.33	0.33	0.33	0.33
18	Shanghai	0.00	0.00	0.00	0.00	0.00
19	Shenzhen	0.33	0.33	0.33	0.33	0.33
20	Taiwan	0.33	0.33	0.33	0.33	0.33
21	Tehran	0.33	0.33	0.33	0.33	0.33
22	Tel-Aviv	0.67	0.67	0.67	0.67	0.67
23	Thailand	0.33	0.33	0.33	0.33	0.33
24	Warsaw	0.33	0.33	0.33	0.33	0.33
	Mean	0.28	0.28	0.31	0.31	0.31
	Median	0.33	0.33	0.33	0.33	0.33

No.	Control Group mean-adjusted	1999	2000	2001	2002	2003
1	Hellenic Exchanges	-0.28	0.39	0.36	0.69	0.69
2	Hong Kong	0.39	0.39	0.36	0.36	0.36
3	Singapore	0.39	0.72	0.69	0.69	0.69
4	Deutsche Börse	0.39	0.72	0.69	0.69	0.69
5	Euronext	0.72	0.72	0.69	0.69	0.69
6	London	-0.28	-0.28	-0.31	-0.31	0.03
7	TSX	0.06	-0.28	-0.31	0.03	0.03

No.	Event-adjusted (IPO)	t-2	t-1	t	t+1	t+2
1	Hellenic Exchanges		-0.28	0.39	0.36	0.69
2	Hong Kong		0.39	0.39	0.36	0.36
3	Singapore		0.39	0.72	0.69	0.69
4	Deutsche Börse	0.39	0.72	0.69	0.69	0.69
5	Euronext	0.72	0.72	0.69	0.69	0.69
6	London	-0.28	-0.28	-0.31	-0.31	0.03
7	TSX	-0.28	-0.31	0.03	0.03	
	Mean IPO	0.14	0.19	0.37	0.36	0.53
	Median IPO	0.06	0.39	0.39	0.36	0.69

Table B.6: Diversification Data for Event Studies on IPO

No.	Demutualized Group indexed at Event	1999	2000	2001	2002	2003
1	Singapore (1999)	1.00	0.90	1.10	1.10	1.32
2	TSX (2000)	0.70	1.00	0.80	0.96	1.04
3	Deutsche Börse (2000)	0.90	1.00	1.08	1.58	2.35
4	Euronext (2000)	1.14	1.00	1.41	2.02	2.01
5	London (2000)	0.90	1.00	1.14	1.20	1.27
6	Hong Kong (2000)	0.71	1.00	0.85	0.82	0.90
7	Nasdaq (2001)	0.74	0.97	1.00	0.93	0.69
8	Oslo (2001)	0.69	0.88	1.00	1.00	1.02
9	Philippine (2001)	1.30	2.02	1.00	0.99	0.70
10	Tokyo (2001)	0.94	0.97	1.00	0.95	1.05
11	Swiss Exchange (2002)	0.58	0.74	0.97	1.00	1.02
12	Budapest (2002)	1.32	1.37	0.97	1.00	1.07
13	Lima (2003)	1.59	1.41	1.05	0.93	1.00

No.	Control Group - Indexed at 1999	1999	2000	2001	2002	2003
1	Chicago	1.00	1.35	1.29	1.05	0.88
2	Istanbul	1.00	2.05	1.63	1.45	1.97
3	Jakarta	1.00	1.02	1.04	1.08	1.15
4	JSE South Africa	1.00	1.22	1.51	1.64	1.56
5	Kuala Lumpur	1.00	0.67	0.39	0.37	0.69
6	Ljubljana	1.00	1.20	1.36	1.74	1.44
7	Malta	1.00	1.22	1.27	1.38	1.38
8	NYSE	1.00	1.12	1.51	1.49	1.51
9	Sao Paulo	1.00	0.99	0.88	0.83	1.00
10	Taiwan	1.00	1.06	0.73	0.75	0.69
11	Thailand	1.00	1.02	0.99	1.15	1.71
12	Warsaw	1.00	1.41	0.99	0.72	0.89
	Mean	1.00	1.19	1.13	1.14	1.24
	Median	1.00	1.16	1.15	1.11	1.26

	Control Group - Indexed at 2000	1999	2000	2001	2002	2003
	Mean	0.89	1.00	0.95	0.96	1.06
	Median	0.86	1.00	0.97	0.94	1.08
	Control Group - Indexed at 2001	**1999**	**2000**	**2001**	**2002**	**2003**
	Mean	1.02	1.12	1.00	1.00	1.14
	Median	0.88	1.04	1.00	1.01	1.07
	Control Group - Indexed at 2002	**1999**	**2000**	**2001**	**2002**	**2003**
	Mean	1.05	1.16	1.02	1.00	1.15
	Median	0.90	1.08	0.99	1.00	1.04
	Control Group - Indexed at 2003	**1999**	**2000**	**2001**	**2002**	**2003**
	Mean	0.90	1.03	0.94	0.92	1.00
	Median	0.80	0.93	0.93	0.96	1.00

No.	Control Group mean-adjusted	1999	2000	2001	2002	2003
1	Singapore	0.00	-0.29	-0.03	-0.03	0.08
2	TSX	-0.20	0.00	-0.14	0.00	-0.02
3	Deutsche Börse	0.01	0.00	0.14	0.61	1.29
4	Euronext	0.25	0.00	0.47	1.06	0.95
5	London	0.01	0.00	0.20	0.24	0.21
6	Hong Kong	-0.19	0.00	-0.10	-0.15	-0.16
7	Nasdaq	-0.28	-0.15	0.00	-0.07	-0.45
8	Oslo	-0.33	-0.24	0.00	0.00	-0.11
9	Philippine	0.28	0.91	0.00	0.00	-0.44
10	Tokyo	-0.08	-0.14	0.00	-0.05	-0.08
11	Swiss Exchange	-0.47	-0.42	-0.05	0.00	-0.13
12	Budapest	0.27	0.21	-0.05	0.00	-0.07
13	Lima	0.68	0.38	0.12	0.00	0.00

No.	Event-adjusted (Demutualization)	t-2	t-1	t	t+1	t+2
1	Singapore			0.00	-0.29	-0.03
2	TSX		-0.20	0.00	-0.14	0.00
3	Deutsche Börse		0.01	0.00	0.14	0.61
4	Euronext		0.25	0.00	0.47	1.06
5	London		0.01	0.00	0.20	0.24
6	Hong Kong		-0.19	0.00	-0.10	-0.15
7	Nasdaq	-0.28	-0.15	0.00	-0.07	-0.45
8	Oslo	-0.33	-0.24	0.00	0.00	-0.11
9	Philippine	0.28	0.91	0.00	0.00	-0.44
10	Tokyo	-0.08	-0.14	0.00	-0.05	-0.08
11	Swiss Exchange	-0.42	-0.05	0.00	-0.13	
12	Budapest	0.21	-0.05	0.00	-0.07	
13	Lima	0.12	0.00	0.00		
	Median Demutualization	-0.08	-0.05	0.00	-0.06	-0.06
	Mean Demutualization	-0.07	0.01	0.00	-0.01	0.07

Table B.7: Operating Revenue Data for Event Studies on Demutualization

No.	IPO Group Revenues Indexed at Event	1999	2000	2001	2002	2003
1	Hellenic Exchanges (2000)	1.84	1.00	1.50	0.98	1.22
2	Hong Kong (2000)	0.71	1.00	0.85	0.82	0.90
3	Singapore (2000)	1.11	1.00	1.22	1.22	1.46
4	Deutsche Börse (2001)	0.84	0.92	1.00	1.46	2.17
5	Euronext (2001)	0.80	0.71	1.00	1.43	1.42
6	London (2001)	0.79	0.88	1.00	1.05	1.11
7	TSX (2002)	0.72	1.04	0.83	1.00	1.08

No.	Control Group - Revenues Indexed at 2000	1999	2000	2001	2002	2003
1	Chicago	0.74	1.00	0.96	0.78	0.65
2	Istanbul	0.49	1.00	0.79	0.71	0.96
3	Jakarta	0.98	1.00	1.01	1.05	1.12
4	JSE South Africa	0.82	1.00	1.24	1.35	1.28
5	Kuala Lumpur	1.50	1.00	0.59	0.56	1.04
6	Ljubljana	0.83	1.00	1.13	1.45	1.20
7	Malta	0.82	1.00	1.04	1.12	1.13
8	NYSE	0.89	1.00	1.35	1.33	1.35
9	Sao Paulo	1.01	1.00	0.89	0.83	1.01
10	Taiwan	0.95	1.00	0.69	0.71	0.66
11	Thailand	0.98	1.00	0.98	1.13	1.68
12	Warsaw	0.71	1.00	0.70	0.51	0.63
	Mean	0.89	1.00	0.95	0.96	1.06
	Median	0.86	1.00	0.97	0.94	1.08

	Control Group - Indexed at 2001	1999	2000	2001	2002	2003
	Mean	1.02	1.12	1.00	1.00	1.14
	Median	0.88	1.04	1.00	1.01	1.07

	Control Group - Indexed at 2002	1999	2000	2001	2002	2003
	Mean	1.05	1.16	1.02	1.00	1.15
	Median	0.90	1.08	0.99	1.00	1.04

No.	Control Group mean-adjusted	1999	2000	2001	2002	2003
1	Hellenic Exchanges	0.94	0.00	0.56	0.02	0.16
2	Hong Kong	-0.19	0.00	-0.10	-0.15	-0.16
3	Singapore	0.21	0.00	0.27	0.26	0.40
4	Deutsche Börse	-0.19	-0.19	0.00	0.46	1.03
5	Euronext	-0.22	-0.41	0.00	0.43	0.28
6	London	-0.23	-0.24	0.00	0.05	-0.02
7	TSX	-0.33	-0.12	-0.19	0.00	-0.06

No.	Event-adjusted (IPO)	t-2	t-1	t	t+1	t+2
1	Hellenic Exchanges		0.94	0.00	0.56	0.02
2	Hong Kong		-0.19	0.00	-0.10	-0.15
3	Singapore		0.21	0.00	0.27	0.26
4	Deutsche Börse	-0.19	-0.19	0.00	0.46	1.03
5	Euronext	-0.22	-0.41	0.00	0.43	0.28
6	London	-0.23	-0.24	0.00	0.05	-0.02
7	TSX	-0.12	-0.19	0.00	-0.06	
	Mean IPO	-0.19	-0.01	0.00	0.23	0.24
	Median IPO	-0.20	-0.19	0.00	0.27	0.14

Table B.8: Operating Revenue Data for Event Studies on IPO

Appendix C

Chapter 5

C.1 Data Envelopment Analysis

In the following we will discuss the linear programs involved in DEA in more detail.

Consider DMU_1 from a sample of n decision making units. Assume that this DMU uses one type of input and generates one type of output. Then, taking the output-to-input-ratio will not be very informative - save for the fact that a higher ratio generally indicates higher efficiency - unless DMU_1's ratio is compared to efficiency values of the other $n-1$ DMUs. Calculating the ratios for all n DMUs and normalizing them[1] yields *relative* efficiency values that can be interpreted in a meaningful way.

The multiplier and envelopment program The basic DEA input-oriented model[2] introduced by Charnes, Cooper, and Rhodes (1978) is based on the same simple intuition, but generalizes the ratio for the multiple input and multiple output case.[3] They calculate an efficiency ratio by assigning an efficiency-optimized *weighting* scheme to the respective outputs and inputs so that one aggregated 'virtual' output value is divided by one aggregated 'virtual' input value. To be more precise, assume that DMU_1 has an $(m \times 1)$ input vector $X_1 = \{x_{l1}\}$ with $l = 1, ..., m$ and an $(s \times 1)$ output vector $Y_1 = \{y_{r1}\}$ with $r = 1, ..., s$.[4] Further assume that there exists a weighting vector ν for the inputs and a second weighting vector μ for the outputs with corresponding dimensions. Then, the non-linear program

$$\begin{array}{llcll} & \max\limits_{\nu,\mu} \quad \dfrac{\mu' Y_1}{\nu' X_1} & & & \\ s.t. & \dfrac{\mu' Y_i}{\nu' X_i} & \leq & 1 & \forall i = 1, ..., n \\ & \mu, \nu & \geq & 0 & \end{array} \tag{C.1}$$

states that the efficiency of DMU_1, i.e. the output-input-ratio weighted by the transposed multipliers μ' and ν', is maximized by optimizing the weighting factors subject to the n constraints requiring that none of the DMU's efficiency value exceeds the value of one when the same weighting scheme is used.[5] However, the non-linear program has an infinite number of solutions. By adding the constraint $\nu' X_1 = 1$ to the program, the denominator of the efficiency ratio can be normalized to one so that the program's objective function becomes linear. The linearization of the constraints is accomplished by multiplying $\nu' X_i$ to constraint i $\forall i = 1, ..., n$. The resulting linear 'multiplier' program then has the following form:

---

[1] This is accomplished by setting a maximum achievable value of one. Hence, perfect efficiency is achieved at a ratio of one while a value of zero indicates absolute inefficiency.

[2] Input-oriented models calculate the DMU's efficiency in terms of the employed quantity of inputs in order to produce a given level of output. Output-oriented models on the other hand determine the efficiency by focusing on the level of produced outputs holding the level of inputs constant. Thus, the choice of the model depends on whether the emphasis is on input reduction or output augmentation. It is reasonable to use an input-oriented model when analyzing the stock exchange industry as the inputs can be influenced more directly by the management than the "outputs" which are predominantly influenced by market demand.

[3] Several refinements of DEA have emerged in the literature. An overview provides chapter 3 of Charnes, Cooper, Lewin, and Seiford (1997).

[4] The observations are all non-negative, i.e. $x_{l1}, y_{r1} \geq 0 \quad \forall l, r$.

[5] The fourth line in equation (C.1) requires the multipliers to be non-negative. Furthermore, it is assumed that the technology under consideration is convex and has the property of disposability in its strong version.

$$\begin{array}{llrcll} & \max_{\nu,\mu} & \mu' Y_1 & & & \\ s.t. & & \nu' X_1 & = & 1 & \\ & & \mu' Y_i & \leq & \nu' X_i & \forall i = 1, ..., n \\ & & \mu, \nu & \geq & 0 & \end{array} \tag{C.2}$$

This program is solved n times, i.e. for each DMU individually. When using matrix notation and employing an $(s \times n)$ matrix of outputs denoted as $\mathbf{Y}$, and an $(m \times n)$ matrix of inputs denoted as $\mathbf{X}$ the program in (C.2) can be written as:

$$\begin{array}{llrcl} & \max_{\nu,\mu} & \mu' Y_1 & & \\ s.t. & & \nu' X_1 & = & 1 \\ & & \mathbf{Y}' \mu & \leq & \mathbf{X}' \nu \\ & & \mu, \nu & \geq & 0 \end{array} \tag{C.3}$$

The program now yields a unique solution for ν^* and μ^*.[6]

The dual program The *dual* of equation (C.3), termed as the "envelopment-problem", is usually preferred to the multiplier problem due to lesser calculation effort.[7] It also provides a different point of view to the problem. In particular, the envelopment problem

$$\begin{array}{llrcl} & \min_{\theta,\lambda} & \theta & & \\ s.t. & & \theta X_1 & \geq & \mathbf{X}\lambda \\ & & Y_1 & \leq & \mathbf{Y}\lambda \\ & & \lambda & \geq & 0 \end{array} \tag{C.4}$$

solves for the highest possible radial contraction, i.e. the minimum value of θ, with which the analyzed input vector (X_1) uses at least as many inputs as a linear combination of observations from the reference or best practice set $(\mathbf{X}\lambda)$ while producing (Y_1) at most as many outputs as the linear combination of best performing peers $(\mathbf{Y}\lambda)$.

Assumptions on technology The presented linear program has a relatively strong assumption about the underlying technology. It restricts the input-output-process to a constant returns-to-scale (CRS) environment. A slightly refined version introduced by Banker, Charnes, and Cooper (1984) weakens this assumption and calculates efficiency scores in a variable returns-to-scale (VRS) surrounding, i.e. it allows for varying returns-to-scale characteristics for different levels of input-output combinations. This is accomplished by adding a further constraint to problem (C.4), namely $\mathbf{1}\lambda = 1$, so that the reference point of the analyzed DMU is now required to be a *convex* linear combination of efficient DMUs.

[6] Linear programs are solved by the Simplex-Algorithm.

[7] As the number of DMUs $(= n)$ is usually larger than the sum of the inputs and outputs $(m + s)$ used in the program, the dual needs to calculate $n - (m + s)$ fewer constraint.

C.2 Malmquist Productivity Index

In order to determine the aggregate change in factor productivity, Färe et al. define input distance functions - that are the reciprocals of Farrell's technical efficiency measure - with respect to the two adjacent time periods in such a manner that they measure the maximum proportional change in inputs required to make (x^{t+1}, y^{t+1}) feasible in relation to technology T^t and make (x^t, y^t) feasible in relation to T^{t+1}.[8] They define the productivity index as the geometric mean of two mixed period distance functions[9]:

$$MQ(x^{t+1}, y^{t+1}, x^t, y^t) = \sqrt{\frac{D^t(x^{t+1}, y^{t+1})}{D^t(x^t, y^t)} \cdot \frac{D^{t+1}(x^{t+1}, y^{t+1})}{D^{t+1}(x^t, y^t)}} \tag{C.5}$$

where the first factor uses time period t and the second factor time period $t+1$ as the respective reference technology. Equation (C.5) can be transformed into the following equation which uncovers the two decomposed effects stated earlier.

$$\begin{aligned} MQ(x^{t+1}, y^{t+1}, x^t, y^t) &= \frac{D^{t+1}(x^{t+1}, y^{t+1})}{D^t(x^t, y^t)} \cdot \sqrt{\frac{D^t(x^{t+1}, y^{t+1})}{D^{t+1}(x^{t+1}, y^{t+1})} \cdot \frac{D^t(x^t, y^t)}{D^{t+1}(x^t, y^t)}} \\ MQ &= \Delta EFF \cdot \Delta TECH \end{aligned}$$

The factor outside the square root indicates the change in efficiency as it is equivalent to the ratio of Farrell's technical efficiency for periods t and $t+1$. The factor under the square root displays the geometric mean of shifts in technology at output levels y^t and y^{t+1}, respectively. The calculation of the distance functions can again be illustrated by figure 5.5:

$$MQ(x^{t+1}, y^{t+1}, x^t, y^t) = \frac{0d/0f}{0a/0b} \sqrt{\frac{0d/0e}{0d/0f} \cdot \frac{0a/0b}{0a/0c}} \tag{C.6}$$

Note that for both factors, a value of one indicates no change whereas a value above (below) one signifies a positive (negative) change in technology and efficiency. Note further that exchanges that possess a low DEA-efficiency value will possess a larger potential to improve their productivity than exchanges that are already highly efficient. In the extreme, an exchange that is fully efficient in two adjacent periods cannot improve its technical efficiency at all. Therefore, we need to treat comparisons between factor productivity gains of highly efficient and less efficient exchanges with caution.[10]

For the m-input/s-output case, the following four DEA-like linear programs need to be solved for all $i = 1, ..., n$ DMUs in order to calculate the respective productivity scores[11], keeping in mind that the required input distance functions are the reciprocal of Farrell's input-oriented technical efficiency measure. Thus,

[8] The methodology of Färe et al. for the output-oriented index is adapted here for the input-oriented approach. Confer Färe, Grosskopf, Norris, and Zhang (1994, p.69-70)

[9] The measurement of productivity in the VRS-case has to be treated with caution since the results could be flawed as was noted by Grifell-Tatjé and Lovell (1995). Additionally, Färe, Grosskopf, Norris, and Zhang (1994, p.73 FN 15) note that solutions from the mixed-period distance functions might not be feasible.

[10] In our second stage regressions we will control for this effect by employing the exchanges' efficiency values as additional independent control variable.

[11] Confer Fried, Lovell, and Schmidt (1993, p. 180-186).

$$
\begin{aligned}
[D^t(x_1^t, y_1^t)]^{-1} &= \min_{\theta,\lambda} \quad \theta \\
s.t. \qquad \theta X_1^t &\geq \mathbf{X}^t\lambda \\
Y_1^t &\leq \mathbf{Y}^t\lambda \\
\mathbf{1}\lambda &= 1 \quad (only\ for\ VRS) \\
\lambda &\geq 0
\end{aligned}
\tag{C.7}
$$

gives the distance function $D_1^t(x_1^t, y_1^t)$ of DMU 1. Similarly, $D_1^{t+1}(x_1^{t+1}, y_1^{t+1})$ is calculated by substituting the indices t by $t+1$ in equation (C.7). The remaining two linear problems are mixed period calculations meaning that the reference technology is constructed from data of period t (and $t+1$, respectively), whereas the input-output-combinations to be evaluated are from period $t+1$ (and t, respectively). Hence, they provide solutions for $D_1^t(x_1^{t+1}, y_1^{t+1})$ and $D_1^{t+1}(x_1^t, y_1^t)$:

$$
\begin{aligned}
[D^t(x_1^{t+1}, y_1^{t+1})]^{-1} &= \min_{\theta,\lambda} \quad \theta \\
s.t. \qquad \theta X_1^{t+1} &\geq \mathbf{X}^t\lambda \\
Y_1^{t+1} &\leq \mathbf{Y}^t\lambda \\
\mathbf{1}\lambda &= 1 \quad (only\ for\ VRS) \\
\lambda &\geq 0
\end{aligned}
\tag{C.8}
$$

and

$$
\begin{aligned}
[D^{t+1}(x_1^t, y_1^t)]^{-1} &= \min_{\theta,\lambda} \quad \theta \\
s.t. \qquad \theta X_1^t &\geq \mathbf{X}^{t+1}\lambda \\
Y_1^t &\leq \mathbf{Y}^{t+1}\lambda \\
\mathbf{1}\lambda &= 1 \quad (only\ for\ VRS) \\
\lambda &\geq 0
\end{aligned}
\tag{C.9}
$$

C.3 Descriptive Statistics

Operational Variables

INPUTS	x1		x2	
	Staff (No. Employed)		Tangible Assets ($ 000)	
	Mean	Std. Dev.	Mean	Std. Dev.
1999	558.5	494.4	60,022	75,947
2000	591.0	503.3	67,704	84,542
2001	615.0	529.7	79,143	91,690
2002	682.3	720.6	91,852	105,551
2003	658.1	696.8	91,670	102,105

OUTPUTS	y1		y2		y3		y4	
	Listing (No. of companies)		Cash Trading (Volume in $ 000 000)		Derivatives Trading (No. of contracts in 000)		Posttrade/Software ($ 000)	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
1999	858.1	1071.1	1,511,495	2,663,612	26,430	76,181	25,152	48,678
2000	876.3	1056.7	2,105,375	4,231,607	33,024	89,092	31,900	66,163
2001	817.5	924.7	1,517,787	2,884,889	47,298	124,285	39,976	78,829
2002	797.9	868.3	1,440,771	2,586,961	63,260	174,780	53,985	124,713
2003	901.2	1007.3	1,202,790	2,277,716	74,936	198,740	65,976	167,821

Resulting Dependent Variables for the Second Stage

	MQ (CRS)		ΔEFF (CRS)		ΔTECH (CRS)	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
1999-2000	1.011	0.273	1.053	0.291	0.970	0.125
2000-2001	1.090	0.433	1.112	0.481	0.988	0.084
2001-2002	1.002	0.157	0.958	0.205	1.069	0.148
2002-2003	1.113	0.251	0.913	0.253	1.260	0.264

	MQ (VRS)		ΔEFF (VRS)		ΔTECH (VRS)	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
1999-2000	1.027	0.283	1.032	0.293	1.008	0.110
2000-2001	1.080	0.364	1.162	0.472	0.952	0.129
2001-2002	1.003	0.125	0.973	0.174	1.047	0.122
2002-2003	1.076	0.206	0.935	0.189	1.175	0.238

	EFF(CRS)		EFF(VRS)	
	Mean	Std. Dev.	Mean	Std. Dev.
1999	0.625	0.275	0.709	0.264
2000	0.639	0.295	0.708	0.276
2001	0.661	0.270	0.771	0.264
2002	0.631	0.293	0.756	0.299
2003	0.580	0.320	0.705	0.314

Independent Framework Variables of the Second Stage

	LISTED	OUTSOURCING	FULL INTEGRATION
	Sum	Sum	Sum
1999	2	5	1
2000	5	7	3
2001	8	7	4
2002	9	8	6
2003	9	7	6

	VERTICAL	HORIZONTAL	HORI-VERTICAL
	Sum	Sum	Sum
1999	5	10	5
2000	6	6	6
2001	5	6	7
2002	4	6	6
2003	5	8	6

	FOREIGN LISTING		LIQUIDITY	
	Mean	Std. Dev.	Mean	Std. Dev.
1999	0.026	0.046	0.680	0.535
2000	0.031	0.071	1.038	1.103
2001	0.028	0.058	0.812	0.746
2002	0.028	0.059	0.881	0.772
2003	0.013	0.021	0.699	0.518

	Δ LT FINANCE		Δ TRADING	
	Mean	Std. Dev.	Mean	Std. Dev.
1999	0.416	0.899	0.130	0.614
2000	0.165	0.271	0.030	0.515
2001	0.286	0.392	-0.006	0.292
2002	0.095	0.240	0.035	0.275
2003	0.079	0.273	0.101	0.388

Table C.1: Descriptive Statistics for Employed First and Second Stage Variables

C.4 First Stage Results

	Constant Returns-To-Scale								
	DEA Technical Efficiency					Malmquist Productivity Index			
	1999	2000	2001	2002	2003	99-00	00-01	01-02	02-03
NASDAQ	1.00	1.00	0.78	0.66	0.76	1.00	0.79	0.82	1.24
NYSE	0.48	0.49	0.57	0.51	0.60	1.02	0.92	0.96	0.96
Toronto TSX	0.72	0.83	0.77	0.84	1.00	0.97	0.86	1.08	1.70
Lima	0.74	1.00	1.00	1.00	0.81	1.06	1.07	1.04	1.05
BOVESPA	0.53	0.49	0.61	0.81	1.00	1.02	1.39	1.15	1.40
Hellenic	0.50	0.17	0.56	0.34	0.44	0.28	3.12	0.79	1.50
Budapest	0.22	0.24	0.33	0.32	0.31	1.02	1.25	0.89	1.34
Copenhagen	1.00	1.00	1.00	1.00	1.00	1.00	0.92	1.00	1.00
Deutsche Börse	1.00	1.00	1.00	0.66	0.98	1.00	1.00	0.79	1.57
Euronext	1.00	1.00	1.00	1.00	1.00	1.07	1.00	1.00	1.01
Istanbul	0.17	0.20	0.17	0.15	0.13	1.02	0.83	0.94	1.08
Johannesburg JSE	1.00	1.00	1.00	1.00	0.44	1.00	0.99	1.03	0.49
London	0.83	0.97	1.00	1.00	1.00	1.02	1.06	1.00	1.00
Malta	0.40	0.28	0.24	0.22	0.19	0.83	0.82	1.24	0.97
Oslo	0.67	0.75	0.75	0.66	0.37	1.01	0.91	0.82	0.96
OM Gruppen	0.91	0.75	0.91	1.00	1.00	1.05	1.45	0.95	1.00
SWX Zurich	0.70	1.00	0.81	1.00	1.00	1.56	0.84	1.08	1.07
Vienna	0.36	0.39	0.39	0.54	0.28	0.97	0.96	1.32	1.05
Warsaw	0.29	0.31	0.24	0.23	0.18	0.92	0.81	0.96	1.07
Australian	0.82	0.94	0.95	0.99	0.68	1.04	0.96	1.09	1.06
Hongkong	0.36	0.68	0.64	0.53	0.52	1.95	0.90	1.07	1.19
Jakarta	0.40	0.36	0.39	0.45	0.36	0.81	1.01	1.19	1.24
Kuala Lumpur	0.69	0.54	0.70	0.30	0.34	0.88	1.22	0.57	1.38
Phillippine	0.38	0.48	0.38	0.33	0.23	1.04	0.92	0.95	0.99
Singapore SGX	1.00	0.51	0.61	0.49	0.28	0.59	1.13	1.09	0.68
Taiwan	0.23	0.30	0.36	0.42	0.25	1.11	1.12	1.13	1.04
Thailand	0.59	0.55	0.56	0.41	0.33	0.96	0.99	0.95	0.96
Tokyo	0.50	0.67	0.79	0.82	0.75	1.10	1.29	1.16	1.17
Mean	0.63	0.64	0.66	0.63	0.58	1.01	1.09	1.00	1.11
Standard Deviation	0.28	0.29	0.27	0.29	0.32	0.27	0.43	0.16	0.25

	Variable Returns-To-Scale								
	DEA Technical Efficiency					Malmquist Productivity Index			
	1999	2000	2001	2002	2003	99-00	00-01	01-02	02-03
NASDAQ	1.00	1.00	1.00	1.00	1.00	1.00	0.90	0.94	1.00
NYSE	0.53	0.62	1.00	1.00	1.00	1.35	0.89	0.97	0.98
Toronto TSX	1.00	1.00	1.00	1.00	1.00	1.00	0.93	1.00	1.53
Lima	0.99	1.00	1.00	1.00	1.00	1.03	1.06	1.03	1.04
BOVESPA	0.57	0.50	0.62	0.82	1.00	1.02	1.37	1.14	1.38
Hellenic	0.67	0.18	0.60	0.35	0.47	0.29	2.76	0.79	1.49
Budapest	0.44	0.65	1.00	1.00	1.00	1.15	1.28	1.04	1.02
Copenhagen	1.00	1.00	1.00	1.00	1.00	1.00	0.95	1.00	1.00
Deutsche Börse	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.28
Euronext	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Istanbul	0.21	0.21	0.18	0.16	0.16	0.93	0.80	0.92	1.11
Johannesburg JSE	1.00	1.00	1.00	1.00	0.47	1.00	1.00	1.00	0.51
London	0.85	0.97	1.00	1.00	1.00	1.01	1.01	1.00	1.00
Malta	1.00	1.00	1.00	1.00	1.00	0.91	0.96	1.00	0.98
Oslo	0.83	0.79	0.78	0.68	0.67	0.97	0.92	0.85	1.03
OM Gruppen	0.92	0.76	0.92	1.00	1.00	1.05	1.44	0.95	1.00
SWX Zurich	0.70	1.00	0.81	1.00	1.00	1.52	0.83	1.08	1.07
Vienna	0.53	0.59	0.70	0.79	0.78	0.99	0.94	1.19	1.06
Warsaw	0.32	0.32	0.25	0.24	0.24	0.92	0.83	1.00	1.13
Australian	0.85	1.00	1.00	1.00	0.69	1.07	0.98	1.05	1.05
Hongkong	0.37	0.68	0.65	0.58	0.53	1.98	0.91	1.08	1.19
Jakarta	0.43	0.37	0.40	0.45	0.42	0.81	1.00	1.19	1.16
Kuala Lumpur	0.73	0.55	0.70	0.33	0.35	0.88	1.22	0.59	1.34
Phillippine	0.53	0.51	0.38	0.33	0.29	1.02	0.90	0.95	0.99
Singapore SGX	1.00	0.52	0.61	0.50	0.29	0.59	1.14	1.09	0.69
Taiwan	0.28	0.33	0.44	0.53	0.26	1.19	1.03	1.21	1.03
Thailand	0.61	0.56	0.56	0.42	0.35	0.97	0.99	0.95	0.96
Tokyo	0.51	0.71	1.00	1.00	0.75	1.11	1.19	1.07	1.10
Mean	0.71	0.71	0.77	0.76	0.70	1.03	1.08	1.00	1.08
Standard Deviation	0.26	0.28	0.26	0.30	0.31	0.28	0.36	0.13	0.21

Table C.2: First Stage Results

C.5 Correlation Matrices

1st and 2nd Stage Variables	x^1	x^2	y^1	y^2	y^3	y^4
HORIZONTAL	-0.292	-0.256	-0.284	-0.210	-0.029	-0.212
VERTICAL	-0.213	-0.271	-0.243	-0.160	-0.164	-0.132
HORI-VERTICAL	-0.023	0.025	-0.013	-0.153	-0.147	-0.024
FULL INTEGRATION	0.571	0.212	0.038	0.033	0.595	0.678
OUTSOURCING	-0.379	-0.183	-0.180	-0.071	-0.189	-0.210
LISTED	0.412	0.171	0.108	-0.050	0.327	0.462
LIQUIDITY	0.393	0.383	0.510	0.568	0.177	0.154
ΔTRADING	0.036	0.062	0.091	0.094	-0.067	-0.023
FOREIGN LISTING	0.342	0.540	0.694	0.834	0.012	-0.038
ΔLT FINANCE	-0.014	-0.070	-0.066	0.025	0.056	0.017

Table C.3: Correlation matrix for first and second stage variables

	2nd Stage Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
(1)	HORIZONTAL	1	-0.27	-0.31	-0.24	0.16	-0.21	-0.08	-0.18	-0.19	-0.11
(2)	VERTICAL	-0.27	1	-0.24	-0.19	-0.18	-0.17	0	-0.05	-0.19	0.16
(3)	HORI-VERTICAL	-0.31	-0.24	1	-0.21	0.07	0.08	-0.23	0.12	-0.15	-0.1
(4)	FULL INTEGRATION	-0.24	-0.19	-0.21	1	-0.14	0.49	0.14	0.01	-0.04	0.01
(5)	OUTSOURCING	0.16	-0.18	0.07	-0.14	1	-0.04	-0.22	-0.14	-0.09	-0.12
(6)	LISTED	-0.21	-0.17	0.08	0.49	-0.04	1	0.01	-0.06	-0.05	-0.05
(7)	LIQUIDITY	-0.08	0	-0.23	0.14	-0.22	0.01	1	0.13	0.45	0.08
(9)	ΔTRADING	-0.18	-0.05	0.12	0.01	-0.14	-0.06	0.13	1	0.07	0.01
(9)	FOREIGN LISTING	-0.19	-0.19	-0.15	-0.04	-0.09	-0.05	0.45	0.07	1	-0.05
(11)	ΔLTFINANCE	-0.11	0.16	-0.1	0.01	-0.12	-0.05	0.08	0.01	-0.05	1

Table C.4: Correlation matrix for second stage variables

C.6 Robustness Checks

	Regressions with Simple Efficiency and Productivity Measures			
	Efficiency Measures		Productivity Growth Measures	
	(1) Cash Volume/Assets	(2) Cash Volume/Staff	(3) Δ(CashVolume/Assets)	(4) Δ(CashVolume/Staff)
HORIZONTAL	-0.118	-1.144	-0.307	0.345
Std. Err.	*0.204*	*1.057*	*0.413*	*0.464*
VERTICAL	-0.411†	5.817***	-0.884***	0.139
Std. Err.	*0.286*	*1.481*	*0.225*	*0.252*
HORI-VERTICAL	-1.063***	-6.307***	-0.685*	0.697*
Std. Err.	*0.282*	*1.460*	*0.359*	*0.363*
FULL INTEGRATION	-1.032***	-1.494	-0.834**	1.092**
Std. Err.	*0.277*	*1.436*	*0.341*	*0.468*
OUTSOURCING	-0.022	-1.654	-0.280†	-0.654***
Std. Err.	*0.285*	*1.474*	*0.184*	*0.232*
LISTED	-0.354**	-0.625	-0.216	-0.110
Std. Err.	*0.168*	*0.869*	*0.476*	*0.225*
LIQUIDITY	0.296**	-0.418	-0.716***	-0.576***
Std. Err.	*0.117*	*0.608*	*0.066*	*0.04*
ΔTRADING	0.499***	0.743†	-0.240**	-0.298***
Std. Err.	0.096	0.498	0.114	0.076
FOREIGN LISTING	-1.214	16.288**	4.956***	2.509***
Std. Err.	*1.341*	*6.948*	*1.610*	*0.666*
ΔLT FINANCE	0.113†	-0.012	0.068	0.006
Std. Err.	*0.078*	*0.406*	*0.112*	*0.111*
CONST	6.350***	4.107***	1.094***	0.254
Std. Err.	*0.193*	*0.999*	*0.354*	*0.327*
Observations	140	140	112	112
R^2(adj.)/Waldχ^2	0.4586	0.4634	0.167	0.287

Table C.5: Robustness check with alternative measures

	Regression with Bootstrapping (500 Replications, 10% and 15%-Level)							
	Constant Returns-To-Scale				Variable Returns-To-Scale			
	(2) EFF	(3) MQ	(4) ΔEFF	(5) ΔTECH	(6) EFF	(7) MQ	(8) ΔEFF	(9) ΔTECH
HORIZONTAL	-0.072†	-0.096	-0.035	-0.030	-0.120*	-0.004	-0.004	-0.013
Std. Err.	*0.078*	*0.427*	*0.382*	*0.190*	*0.120*	*0.293*	*0.286*	*0.132*
VERTICAL	-0.054	0.555*	0.755*	-0.013	-0.209*	0.502*	0.728*	-0.121
Std. Err.	*0.149*	*0.516*	*0.552*	*0.202*	*0.277*	*0.372*	*0.431*	*0.17*
HORI-VERTICAL	-0.026	0.153	0.267	-0.009	-0.204*	0.171	0.339*	-0.168
Std. Err.	*0.156*	*0.464*	*0.431*	*0.208*	*0.218*	*0.317*	*0.344*	*0.17*
FULL INTEGRATION	-0.053	0.025	0.105	-0.017	-0.192*	0.131	0.156†	-0.059
Std. Err.	*0.174*	*0.426*	*0.375*	*0.245*	*0.303*	*0.309*	*0.248*	*0.19*
OUTSOURCING	0.012	0.084	-0.017	0.167	0.170*	0.033	-0.037	0.119*
Std. Err.	*0.116*	*0.337*	*0.312*	*0.133*	*0.155*	*0.269*	*0.225*	*0.095*
LISTED	0.063	0.093	-0.064	0.168*	0.087	0.068	-0.061	0.137*
Std. Err.	*0.133*	*0.194*	*0.135*	*0.104*	*0.177*	*0.196*	*0.12*	*0.099*
LIQUIDITY	-0.007	-0.043	-0.003	-0.06	-0.052*	-0.033	0.038	-0.063
Std. Err.	*0.056*	*0.104*	*0.147*	*0.091*	*0.099*	*0.09*	*0.106*	*0.070*
ΔTRADING	0.030	-0.126*	-0.120*	0.003	0.059	-0.115*	-0.121*	0.011
Std. Err.	*0.045*	*0.082*	*0.082*	*0.063*	*0.063*	*0.070*	*0.063*	*0.042*
FOREIGN LISTING	1.004*	1.276*	1.100†	0.373	1.559*	0.769	1.107†	-0.444
Std. Err.	*0.997*	*1.050*	*1.210*	*1.638*	*1.187*	*1.066*	*1.11*	*0.953*
ΔLT FINANCE	0.035	-0.092*	-0.023	-0.075†	0.029*	-0.079*	-0.041†	-0.050*
Std. Err.	*0.045*	*0.069*	*0.056*	*0.051*	*0.067*	*0.045*	*0.064*	*0.030*
EFF		-1.369*	-1.813*	0.519*		-0.991*	-1.539*	0.545*
Std. Err.		*0.470*	*0.545*	*0.230*		*0.405*	*0.485*	*0.182*
CONST	0.661*	1.807*	1.972*	0.736*	0.916*	1.642*	1.911*	0.732*
Std. Err.	*0.091*	*0.368*	*0.393*	*0.214*	*0.152*	*0.337*	*0.361*	*0.167*
Observations	140	112	112	112	140	112	112	112

Table C.6: Robustness check with bootstrapping

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Ehrenwörtliche Erklärung

Ich habe die vorgelegte Dissertation selbst verfasst und dabei nur die von mir angegebenen Quellen und Hilfsmittel benutzt. Alle Textstellen, die wörtlich oder sinngemäß aus veröffentlichten oder nicht veröffentlichten Schriften entnommen sind, sowie alle Angaben, die auf mündlichen Auskünften beruhen, sind als solche kenntlich gemacht.

Frankfurt, den 14. August 2006