ISTANBUL TECHNICAL UNIVERSITY ★ GRADUATE SCHOOL OF ARTS AND SOCIAL SCIENCES

COST AND PRICING EFFICIENCY IN CAPITAL MARKET INFRASTRUCTURES: A CLOSER LOOK AT INTEGRATION AND PRODUCT DIVERSIFICATION

Ph.D. THESIS

Seven İPEK

Department of Management

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İSTANBUL TEKNİK ÜNİVERSİTESİ ★ SOSYAL BİLİMLER ENSTİTÜSÜ

SERMAYE PİYASASI ALTYAPI KURUMLARINDA MALİYET VE FİYAT ETKİNLİĞİ: BÜTÜNLEŞME VE ÜRÜN ÇEŞİTLENDİRMEYE DERİNLEMESİNE BİR BAKIŞ

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To my children, Eren and Bahar,

FOREWORD

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ABBREVIATIONS

ASE : American Stock Exchange
ASX : Australian Stock Exchange
ATS : Alternative Trading Systems
BIS : Bank of International Settlements
BIST : Borsa Istanbul Exchange Group
BSE : Bombay Stock Exchange
CEE : Stock Exchange Group Holdings
CBOE : CBOE Global Markets
CCP : Central Counterparty
CMI : Capital market infrastructure
CPMI : Committee on Payments and Market Infrastructure
CSD : Central Securities Depository
CSDL : Central Securities Depository Limited of India
CSDR : Central Securities Depository Regulation
DBG : Deutsche Börse Group
DVP : Delivery versus Payment
ECSDA : European Central Securities Depositories Association
EMIR : European Market Infrastructure Regulation
ESMA : European Securities Market Authority
EU : European Union
FGLS : Feasible Generalized Least Squares
FOP : Free of Payment
FSB : Financial Stability Board
GLS : Generalized Least Squares
GDP : Gross domestic product
GDPC : Gross domestic product per capita
HKEX : Hong Kong Stock Exchange
ICE : The International Stock Exchange Group (USA)
ICSD : International Central Securities Depository
IOSCO : International Organization of Securities Commissions
IT : Information Technology
JASDEC : Japan Securities Depository
JPX : Japan Exchange Group
JSE : Johannesburg Stock Exchange
KRX : Korea Exchange
LIFFE : London International Financial Futures and Options Exchange
LME : London Metals Exchange
LSE : London Stock Exchange
LSEG : London Stock Exchange Group
MTF : Multilateral Trading Facility
MiFID : Markets in Financial Instruments Directive
MiFIR : Markets in Financial Instruments Regulation

MOEX	**:** Moscow Exchange Group
NGX	**:** Natural Gas Exchange
NPR	**:** Net profit ratio
NSDL	**:** National Securities Depository of India
NSE	**:** National Stock Exchange of India
NYSE	**:** New York Stock Exchange
OCC	**:** Options Clearing Corporation (USA)
OLS	**:** Ordinary Least Squares
OTC	**:** Over the Counter
PTS	**:** Proprietary Trading System
SEF	**:** Swap Execution Facility
SFTR	**:** Securities Financing Transactions Regulation
SGX	**:** Singapore Stock Exchange
SMX	**:** Singapore Mercantile Exchange
SSS	**:** Securities Settlement System
T+2	**:** Trade cycle, trade date plus 2 days
TFX	**:** Tokyo Financial Exchange
WFE	**:** World Federation of Exchanges

SYMBOLS

AC	: Average cost
BIM	: Business integration model
bo	: Market beneficial ownership type
data	: Diversification to data and information services business lines
dex	: Sole specific derivatives exchange
diff	: Asset type differentiation
DIV	: Diversification in functions or business activities
ε_d	: Cost output elasticity of derivatives contracts processed
ε_{sec}	: Cost output elasticity of securities transactions processed
e_{it}	: Idiosyncratic error term
horiz	: Horizontally integrated
i	: Entity indicator
indep	: Independent (non-integrated)
Ln	: Natural logarithm
multi	: Both horizontally and vertically integrated
N	: Normal distribution
N^+	: Truncated normal distribution
NI	: Net income before tax
NPR	: Net profit ratio
η	: Decay parameter
P	: Price level
Q_d	: number of derivatives transactions processed
Q_{sec}	: Number of securities transactions processed
REG	: Region
reg_ap	: Region Asia Pacific
reg_eurp	: Region Europe
reg_india	: Region India
reg_us	: Region USA
scale	: Cost output elasticity
t	: Time indicator
T	: Last period
TC	: Total operating costs
TR	: Total operating revenue
v_i	: Time invariant entity specific technical inefficiency component
v_{it}	: Technical inefficiency term
u_i	: Entity-specific time-invariant error term
μ	: Expected technical inefficiency
σ^2	: Variance
vert_exccp	: Exchange integrated with the CCP
vert_silo	:Silo model integrated exchange
Z	: Integer

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COST AND PRICING EFFICIENCY IN CAPITAL MARKET INFRASTRUCTURES: A CLOSER LOOK AT INTEGRATION AND PRODUCT DIVERSIFICATION

SUMMARY

Capital market infrastructures (CMIs) are exchanges, central counterparties (CCPs) and central securities depositories (CSDs). Exchanges provide trade execution, CCPs clearing and CSDs settlement services for the secondary markets. Business integration models are horizontal integration across market places or vertical integration in the value chain. Multiway integration embraces both horizontal and vertical integrations. Integration is the consolidation of organizations' management in one reporting entity. Most horizontal and multiway integrations take place in the developed markets, especially in the US and Europe. Emerging markets are characterized with vertical integration. In the emerging markets integration and diversification strategies are limited within the national borders in general. In developed markets horizontal integrations among market places, or multiway integrations and product diversifications took place through mergers and acquisitions.

In our empirical analysis, we exclusively analyze the performance of CMIs as "transaction processing factories". We try to assess whether business integration or product diversification increases their efficiency. Our main research question is how business integration or product diversification affect cost and pricing efficiency of the CMIs. We use frontier and random-effects panel regressions on a dataset of 34 CMIs from 22 countries for 5 years. We analyze the effect of business integration model and diversification aspects on total cost, average cost, utilization of economies of scale and profitability.

We found that business integration reduces costs in the long run. Securities markets are more mature compared to the derivatives markets. Vertical integration of the whole CMI value chain in silo model reduces costs in the long run. Diversification in the form of asset class differentiation reduces costs both in the short and long run for the exchanges. It also increases exchanges' profitability. CMIs industry in the US market is associated with highest cost efficiency. Entity size matters for the emerging world, both for cost efficiency and profitability. In case emerging market CMIs archive to integrate more, they will reduce the costs; consequently, these CMIs could also benefit from increased profits. Technological improvements over time reduces costs significantly in developed markets. Our results yield implications for policy makers and CMIs in developed and emerging markets, from both short- and long-run perspectives, in both cost and economic efficiency aspects, and for all types of CMIs.

SERMAYE PİYASASI ALTYAPI KURUMLARINDA MALİYET VE FİYAT ETKİNLİĞİ: BÜTÜNLEŞME VE ÜRÜN ÇEŞİTLENDİRMEYE DERİNLEMESİNE BİR BAKIŞ

ÖZET

Borsalar, merkezi takas ve karşı taraf kurumları ile merkezi saklama kurumları sermaye piyasası altyapı endüstrisini oluşturmaktadır. Borsalar piyasa işletimi ve kotasyon, merkezi karşı taraf kurumları takas ve merkezi karşı taraf, merkezi saklama kurumları ise mutabakat ve menkul kıymet ihraç altyapısı sağlamaktadır. Altyapı hizmetleri sermaye piyasalarında temel yapı taşı görevini üstlenmektedir. Sermaye piyasalarına ilişkin geniş bir literatür olmasına rağmen, altyapı kurumlarının endüstriyel yapısına ilişkin literatür çok kısıtlıdır.

Aracı kuruluş birlikleri olarak kurulan altyapı kurumları zaman içinde şirketleşmiş; birleşme ve satın almalar ile konsolidasyon sürecinden geçmiştir. Bu süreç hali hazırda da küresel çapta devam etmektedir. Bu birleşme ve satın almalar, bütünleşme ve ürün çeşitlendirme stratejilerinin uygulanması şeklinde altyapı kurumlarının organizasyon ve yönetim yapısını değiştirmiştir. Yatay, dikey ve çok yönlü bütünleşme modelleri uygulanabilmektedir. Bunun yanında, farklı menkul kıymet sınıflarında hizmet sunma, veri hizmetleri sunma gibi ilişkili hizmet kollarında faaliyet göstererek ürün çeşitlendirme stratejileri de uygulanmaktadır. Endüstrideki bu etkilerin analiz edildiği akademik çalışma sayısı oldukça azdır. Mevcut çalışmalarda sadece borsa veya sadece merkezi saklama kurumları incelenmiştir. Teorik çalışmalar ise yalnızca belirli stratejilerin etkileri üzerinde durmaktadır. Mevcut yazında daha çok gelişmiş piyasalardaki altyapı kurumlarını incelemekte, gelişmekte olan piyasalar kapsam dışında kalmaktadır. Bu sebeple, bu tezde amacımız sermaye piyasası altyapı kurumları için kapsamlı bir endüstri analizi çalışması yaparak, yazındaki bu açığı kapatmaktadır. Çalışmalarımızda bütünleşme ve ürün çeşitlendirme stratejilerinin maliyet ve fiyatlama verimliliğine etkileri incelenmektedir.

Tez dört temel ayaktan oluşmaktadır. Öncelikle, sermaye piyasası altyapı hizmetleri değer zincirine ilişkin fonksiyonlar ile bütünleşme ve ürün çeşitlendirme stratejileri detaylı olarak tanımlanmaktadır. İkinci olarak, dünya çapında altyapı kurumları tanıtılmış, bu kurumların tarihi gelişimi ve piyasa özellikleri üzerinde durulmuştur. Üçüncü olarak, altyapı kurumlarına ilişkin yazın kapsamlı bir şekilde gözden geçirilmiştir. Son olarak, dünya altyapı kurumlarının mevcut yapısı ve ekonomik yazın ışığında ampirik bir analiz yapılmıştır. Analizde, uygulanmakta olan bütünleşme ve ürün çeşitlendirme stratejilerinin maliyet ve karlılığa etkileri incelenmiştir.

Yatay bütünleşme, farklı piyasalarda değer zincirinde aynı seviyede altyapı faaliyeti gösteren kurumların birleşmesidir. Dikey bütünleşme değer zincirindeki borsa, takas ve saklama altyapı kurumlarının birleşmesidir. Çok yönlü bütünleşme ise yatay ve

dikey bütünleşme türlerinin farklı şekillerde bir arada uygulanmasıdır. Bütünleşen altyapı kurumları organizasyonu tek bir yönetimde toplamakta ve konsolide finansal rapor hazırlamaktadır. Ürün çeşitlendirme, altyapı kurumlarının ana faaliyetleri dışında farklı tipte sermaye piyasası araçları için altyapı sunmaya başlaması, bankacılık veya veri yayını gibi ilgili yan hizmet dallarında faaliyet göstermeye başlamasıdır. Bu faaliyetlerin tamamı aynı konsolide finansal raporlama altında gerçekleştirilmektedir.

Sermaye piyasaları altyapı kurumları küresel çapta incelendiğinde yatay ve çok yönlü birleşmeler gelişmiş ülkelerde, özellikle de Avrupa ve ABD piyasalarında gözlenmektedir. Gelişmekte olan ülkelerde ise dikey bütünleşme ön plandadır. Yasal mevzuat ve piyasada vekil hesap yapısının uygulanması altyapı kurumlarının uygulayabilecekleri bütünleşme ve ürün çeşitlendirme stratejilerini etkilemektedir. Bu sebeplerden dolayı, gelişmekte olan ülkelerde konsolidasyon ulusal sınırlar içinde kalmaktadır. Bu tezde, altyapı kurumları arasındaki birleşme satın almalar küresel anlamda sınıflandırılarak bütünleşme ve ürün çeşitlendirme dalgaları analiz edilmiştir. Böylece bu iş kolu için dünya çapında bir birleşme tasnifi yapılmıştır. Bununla birlikte, dünya sermaye piyasaları altyapı kurumlarının haritası çıkartılmıştır. Bu iki analiz, endüstri yapısı yazınına iki önemli araç olarak katkı sağlamaktadır.

Ayrıca, endüstri analizinde kullanılacak verimlilik ölçüleri ile mevcut bütünleşme yazını detaylı olarak incelenmiş ve tartışılmıştır. Maliyet verimliliği en az girdi ile en yüksek çıktının elde edilmesidir. Altyapı hizmetlerinde çıktı işlem miktarıdır. Bu miktar piyasa katılımcıları tarafından belirlenmektedir. Bu sebeple, işlem miktarı altyapı kurumlarının üretim fonksiyonuna dışsal olarak girmektedir. Altyapı kurumları için işlem miktarı kendi kontrolleri dışında gerçekleştiği için verimliliği artırmak maliyetleri düşürmek ile mümkün olmaktadır. Ekonomik verimlilik ise piyasasının rekabetçi olması ve fiyatların rekabet şartları atında oluşmasıdır. Burada fiyatlar altyapı kurumlarının işlem komisyonlarıdır. Ekonomik verimlilik ekonomik karın olmaması durumudur. Kaynakların verimli kullanıldığı varsayımı altıda, karlılığın azalması ekonomik verimliliği artırmaktadır.

Altyapı kurumlarında bütünleşme ve ürün çeşitlendirme stratejilerinin maliyet ve fiyat verimliliğini etkileyen ampirik çalışma tezin en can alıcı bölümünü oluşturmaktadır. Bu bölümde mevcut endüstri yapısı ve ekonomik yazın ışığında detaylı bir analiz yapılmaktadır. Uluslararası Ödemeler Bankası Ödeme ve Piyasa Altyapısı Komitesi üyesi 22 ülkeden 34 altyapı kurumu incelenmiştir. Analiz, panel veri yöntemi ile yapılmış olup 2012-2016 yılları arsındaki beş yıl analiz kapsamındadır. Çalışma, hem verimliliğin ölçümüne yeni yöntemler getirerek mevcut yazındaki farklı görüşleri açıklamakta, hem de gelişmiş ve gelişmekte olan piyasalardaki tüm altyapı kurum tiplerini kapsamına almaktadır. Bu kadar geniş kapsamlı bir çalışma bildiğimiz kadarı ile yazında bir ilktir. Bu çalışmada, altyapı kurumları, piyasa yapısından bağımsız olarak birer "işlem fabrikası" olarak görülmektedir. İki tür çıktı mevcuttur: işlenen menkul kıymet işlem sayısı ve işlenen türev kontrat sayısı. İşlenen türev kontrat sayısı miktarı genişleme yolu fonksiyonu kullanılarak işlenen menkul kıymet işlem sayısı miktarı cinsinden ifade edilmiş, böylece toplam çıktı miktarı işlenen menkul kıymet işlem sayısı miktarı cinsinden tahmin edilmiştir. Toplam maliyetler tahmin edilen çıktı miktarına bölünerek ortama maliyet tahmin edilmiştir. Ortalama maliyet kısa vadeli maliyetleri ölçmekte kullanılmıştır. Toplam maliyet ise ikinci derece logaritmik fonksiyon olarak modellenmiştir. Bu fonksiyon, sınır analizi yöntemiyle tahmin edilmiştir. Toplam maliyet fonksiyonuna göre iki çıktı miktarının maliyet çıktı esnekliği (elastisitesi) hesaplanmıştır. Bu esneklik, çıktı ölçeğindeki marjinal bir artışın maliyetleri ne oranda artırdığını göstermektedir ve mikroekonomik analizlerde uzun vadeli maliyetlerin bir göstergesi olarak kullanılmaktadır. Bu çalışmada da, maliyet çıktı esnekliği uzun vadede çıktı ölçeğinin artışına bağlı olarak birim maliyetlerde sağlanan düşüşü, yani maliyet tasarrufunu göstermektedir. Ayrıca, karlılık oranındaki azalış ekonomik verimliliğin/fiyatlama verimliliğinin bir ölçüsü olarak kullanılmıştır. Çalışma, bildiğimiz kadarıyla, yazında bu üç verimlilik ölçüsünün (kısa vadeli maliyet verimliliği, uzun vadeli maliyet verimliliği ve fiyatlama verimliliği) bir arada kullanıldığı ilk çalışmadır. Bu sebeple, kısa ve uzun vadeli maliyet verimliliği ile fiyatlama verimliliği arasındaki ilişki de incelenebilmiştir. Ayrıca, çalışma tüm altyapı kurumlarını (borsa, merkezi karşı tarafı ve merkezi saklama) bir arada analiz eden ilk çalışmadır. Literatürdeki birçok çalışma gelişmiş ülke kurumlarına odaklanmış iken, bu çalışmada gelişmekte olan ülkeler de dahil edilmiştir. Çalışma Türkiye sermaye piyasası altyapı kurumlarını da içeren küresel ölçekli ilk çalışmadır. Bu bakımdan, Türkiye sermaye piyasası altyapı kurumları için dünya çapında bir karşılaştırma imkanı da sağlamaktadır.

Ampirik çalışma sonucunda bütünleşmenin uzun vadede maliyetleri düşürdüğü bulunmuştur. Dikey ve çok yönlü bütünleşmelerde bu etki daha kuvvetlidir. Dikey bütünleşme uzun vadede ölçek ekonomisi kazanımlarını artırmaktadır. Çok yönlü bütünleşme ortalama maliyetleri düşürmekte, uzun vadeli ölçek etkisini artırmakta ve karlılığı artırmaktadır. Çok yönlü bütünleşmenin kısa ve uzun vadede maliyet düşüşü sağlaması ve karlılığı artırması, son yıllarda küresel ölçekte gerçekleşen şirket bileşmelerini ve konsolidasyon teşebbüslerini açıklamaktadır. Ayrıca, menkul kıymet borsalarının türev piyasa işletimi sunarak ürün çeşitlendirme yoluna gitmesinin kısa ve uzun vadede maliyetleri düşürdüğü ve karlılığı artırdığı da görülmüştür. Bu da, menkul kıymet borsalarının türev borsalarını satın alma stratejisini açıklamaktadır. Gelişmekte olan ülkeler için en önemli sonuç, bu ülke altyapı kurumları için şirket büyüklüğünün önemli olduğudur ve altyapı kurumları büyüdükçe maliyetlerin azalarak karlılığın artmasıdır. Günümüzde, birçok gelişmekte olan ülkede altyapı kurumları ulusal sınırlar için konsolidasyonu tamamlayarak, ulusal çapta en yüksek ölçek ve şirket büyüklüğüne ulaşmıştır. Bu altyapı kurumlarında verimlilik artışı için bölgesel veya küresel birleşmeler gereklidir. Zaman içinde kullanılan teknolojinin ilerlemesi gelişmiş ülkelerde maliyetleri düşürmektedir. Gelişmekte olan ülkelerde ise bu etki anlamlı değildir. Çalışma sonuçları, gelişmiş ve gelişmekte olan ülkelerdeki düzenleyicilere sermaye piyasası altyapı endüstrisinde bütünleşme, konsolidasyon ve rekabet kapsamında piyasa düzenlemeleri konusunda; altyapı kurumları yöneticilerine ise bütünleşme ve birleşme stratejileri kapsamında ışık tutmaktadır.

1. INTRODUCTION

Capital market infrastructures (CMIs) are exchanges, central counterparties (CCPs) and central securities depositories (CSDs). Exchanges establish a trading environment that includes trade execution and listing facilities. CCPs and CSDs are post-trade infrastructures. CCPs provide clearing and central counterparty facilities while CSDs provide settlement facilities as well as securities depository services. These are the seamless building blocks of capital markets in the baseline. Although a long literature exists on financial and capital markets in general, there are a limited number of studies on these infrastructure entities. Despite the huge transformation of the industry from broker/dealer associations to global profit oriented networks, the literature on the effects of business integration models and product diversification is short and partial. The analysis exclusively focuses on exchanges or post-trade infrastructures. Theoretical literature focuses on specific instances of integration or diversification while empirical studies focus on developed markets. Our aim is to fill the gap in the literature by providing a comprehensive industry analysis that includes all types of CMIs in developed and emerging markets. Our focus is the business integration and product diversification aspects in the CMI industry. We build this dissertation on four major purposes. Our first aim is to provide a detailed and most up to date definition of functions in the CMI value chain. Secondly, we try to find out who the CMIs are and uncover the story behind. Thirdly, we provide a comprehensive literature review on the market design of the industry underlined with integration and diversification aspects. Lastly, we aim to combine the global outlook and economic literature into an empirical design. Consequently, we provide an elaborate empirical study about the effects of the integration and diversification on cost and pricing efficiency.

Initially, we describe general functions of exchanges, CCPs and CSDs. Then, we document the functions of the CMI value chain with a focus on integration and diversification as well as other linkage strategies. This first chapter defines the industry set up and is a crucial glossary that rest of the dissertation is built on.

Secondly, we provide the most up-to-date snapshot of the industry as well as the historical background. In this section, we develop a detailed global map of CMIs by distinguishing the aspects of the developed and emerging markets. We specifically focus on the US and Europe as these two regions shape the general trend worldwide. Regulatory framework and market types are explained as these are the two exogenous factors that affect and change the integration and diversification opportunities. We offer an up-to-date snapshot of regional dispersion, business integration and product diversification in the industry. Then, we turn to a basic question: "How did the CMIs which were established as industry associations turn out to be profit oriented global leaders?" We begin with demutualization as it is the process that makes the path for the mergers and acquisitions. Mergers and acquisitions are the events that we see in the news and financial statements. Business integration and product diversification are brought about by these events. Therefore, integration and diversification are part of the story of mergers and acquisitions. We prepare a comprehensive classification of merger events and the integration and diversification waves they brought to the industry. We also provide a concise literature on the performance of CMIs after mergers with respect to various aspects.

Thirdly, we focus on the economies of the CMI industry. We first describe the market design of the industry. Then we turn our focus to business integration and product diversification. We combine various aspects of integration and diversification mentioned in the literature. We explain how performance is measured in this industry. Cost efficiency is about achieving highest productivity with minimum wasted expense. It focuses on the production function. Economic efficiency (also called "price allocation efficiency") measures the ability of the market to have competitive pricing. It outlines profitability. We give a comprehensive literature about the effects of integration on the CMI performance in terms of cost or pricing efficiency. We also provide insight for the importance of cost reduction in the industry for the whole economy.

Last section is the most extensive one. It embodies all the previous discussions into an empirical industry analysis. In this section, we consider CMIs as transaction processing factories and assess whether business integration or product diversification increases the efficiency of these factories. We neither analyze the market nor investment performance, but the performance of “factory CMIs”, which are the building blocks of the market in the baseline.

Our main research question is how business integration and product diversification affect cost and pricing efficiency of the CMIs. For this purpose, we use frontier and random-effects panel regressions on a dataset of 34 CMIs from 22 countries for 5 years. We analyze the effect of business integration model and diversification aspects on total cost, average cost, utilization of economies of scale and profitability. Short-run cost efficiency is specified by average cost, while long-run cost efficiency is specified by utilization of scale economies. Profitability indicates pricing/economic efficiency. Our analysis is unique in that we evaluate both short-term and long-term effects for developed and emerging markets. Our results for short-run and long-run cost efficiency embrace different theories in CMI integration literature. Moreover, we include in our analysis all types of institutions in the capital market infrastructure value chain while previous studies focus on exchanges or CSDs only. Our results yield implications for policy makers and CMIs in developed and emerging markets, from both short- and long-run perspectives, for both trade and post trade infrastructures.

The structure of the thesis is as follows: Chapter one offers an introduction and explains main research question, purposes and importance of the thesis. In chapter two, we define the CMI value chain. Chapter three provides a global outlook of the industry. Chapter four shows the economies of the industry. Chapter five is in the form of an empirical study on cost and pricing efficiency with more detailed statistical analyses in the Appendix. The last chapter concludes our discussions and results.

2. CAPITAL MARKET INFRASTRUCTURE VALUE CHAIN

2.1 Introduction

Capital market infrastructure institutions (CMIs) are exchanges, clearing houses and central counterparties (CCPs) and central securities depositories (CSDs). Exchanges provide trading infrastructure. CCPs and CSDs are post trade infrastructures.

Exchanges provide listing, order matching/trade execution infrastructure. Conventional regulated exchanges provide both listing and trade execution infrastructures. In recent decades, alternative-trading venues that provide trade execution portals have emerged. They provide trade execution facilities on the securities listed on main regulated exchanges, but they do not provide listing services.

CCPs provide clearing services. In addition, they take the role of buyer to the sell side, and seller to the buy side of the executed trades. In relation to their role as central risk-taking body, they also provide risk and collateral management services. In recent years, regulators all around the world require use of the CCP services on top of clearing for all asset classes including derivatives as well as equities, debt instruments and OTC (over the counter) derivatives.

CSDs provide depository services to the issuers, settlement and custody services to the traders. Issuers deposit the securities at the CSD. Then, the security can be transferred among the traders or investors in the books of the CSD in primary and secondary market transactions. Primary market transactions are the initial offer of securities by the issuer to investors. Whereas, secondary market transactions are the further trades among investors. Settlement operation is simply the transfer of the legal ownership of the securities in CSD books. Today most of the settlement take place delivery versus payment (DVP) form. In DVP settlement, securities transfer in the CSD books take place along with the simultaneous exchange of accompanied cash. Custody services includes safekeeping of the security certificates as well as corporate action services.

2.2 CMI Value Chain

This section discusses the CMIs and the services they provide in detail. CMIs and the services they provide in primary and secondary markets are depicted in Figure 2.1. Primary market services are the services provided to the issuers and investors during the initial offer. Secondary market services are services that are provided to the traders. CMIs also provide market surveillance or reporting functions which are required by the regulators. However, our focus is the main infrastructural functions. Reporting, market surveillance and other regulatory functions of the CMIs are disregarded as they are beyond the scope of the dissertation.

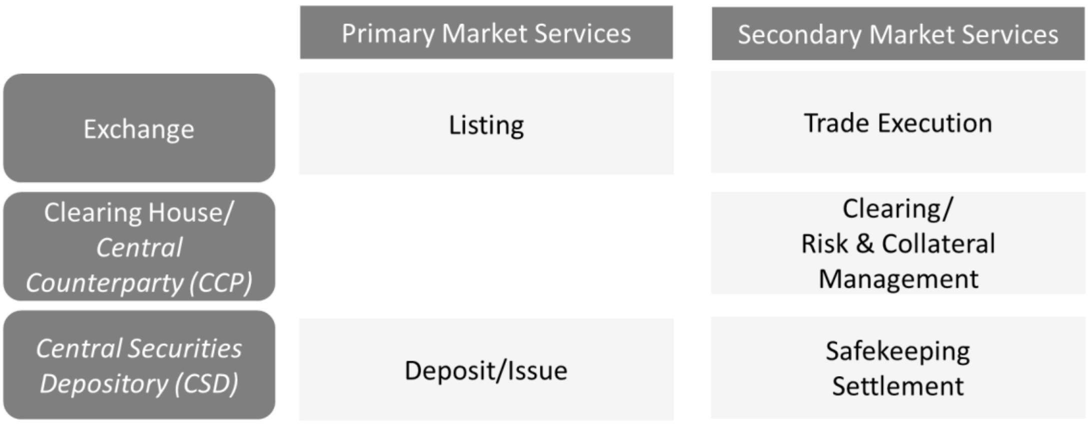


Figure 2.1 : CMIs and infrastructure services.

2.2.1 Exchanges

Listing includes the process of accepting a security to be traded on exchange's trading platform. Listed instruments can be equities, debt instruments, funds, certificates and securitized derivatives issued by the accepted companies. Companies which meet the specific due diligence requirements are accepted. In most cases, exchanges pursue a surveillance mechanism after the initial acceptance as well. Listing is a function of regulated securities exchanges. Derivatives exchanges themselves write the standardized derivatives contracts to be traded on their platforms.

Trade execution is provided by electronic infrastructures where traders' orders are posted, matched and executed within pre-announced specific rules and regulations. These electronic infrastructures are called as trading platforms or trading venues. Traditional trading floors are still available on some conventional exchanges; however, vast majority of trades are executed through electronic trading platforms. Through the electronic systems, the trade participants can submit orders from remote locations, while, co-location has gained importance for high frequency traders.

Two market categories are globally present with respect to the trading structures; dealer and auction markets. In dealer markets, dealers quote buy and sell prices on the trading platform. They are the market makers. Other trading participants, namely brokers, post the amount they want to buy or sell at the price quoted by the dealers. Dealers trade on their own accounts, while brokers are usually agents of other investors. In these markets, dealers are the market makers and they provide liquidity to the market. US is a typical example of dealer markets. In auction markets, trading participants submits their buy or sell orders with the price they want to buy or sell simultaneously to the market. The auction mechanism matches the orders with price and time priority. Availability of buy and sell side orders provide the liquidity in these markets. European markets are traditionally of this type. Today, most of the markets use both dealer and open auction market design for different asset classes. Trade intermediaries, namely, dealers, brokerage houses and banks are the exchange participants or members.

In developed markets, market fragmentation is allowed. In these markets, trade intermediaries may internalize the trade orders that they receive from their clients. Orders conveyed to the exchange or trading venue do not include name or identification of the ordering investors. Intermediaries may also establish trading platforms that accepts trade orders, then, match and execute them. In US and Canada these platforms are named as Alternative Trading Systems (ATS), in Europe Multilateral Trading Facility (MTF) and in Japan Proprietary Trading System (PTS). In emerging markets on the other side, regulated exchanges are the only trading venue available. In these markets, providing liquidity through accumulation of all trade orders on one platform is the focus of the regulators.

2.2.2 Clearing Houses and CCPs

Clearing is the process of netting executed trades and calculating net positions in cash versus securities or derivatives contracts. If the clearinghouse is also serving as central counterparty, then the CCP sets itself between the sell and buy side of the executed trades. To put it differently, CCP stands as buyer to every seller, and seller to every buyer in the market in order to guarantee settlement. Therefore, CCP services also necessitate in depth analysis of market risk as well as sound collateral management. Collateral and default fund mechanisms are crucial to protect interested parties and to keep the system functioning properly. CCP services are relatively more important and dynamic in derivatives markets due to the contracts having a time to maturity. Consequently, risk exposure in derivatives markets are much larger. In securities markets, risk exposure is limited with the trade cycle, mostly two days after the trade date (T+2). Therefore, CCP concept has been more profoundly applied in derivatives markets. Still, in securities markets risk exposures can be high due to high trading volumes, or high level of concentration of specific traders at one side of the trade. Hence, in last two decades, CCP functions are also widely adopted clearing in securities markets.

Clearing members are usually banks or brokerage houses that hold the aggregated settlement positions of their own and their customers' or other members'. Each trading participant in the trading venue assign itself a clearing member in order to process post trade operations at the CCP. There are two types of clearing members. Direct clearing members are authorized for clearing operations of their own house trades and those of their customers. General clearing members are authorized additionally for clearing operations of other members.

As trade execution contract between the buyer and seller is sent to the CCP from the trading venue, the CCP replaces this contract with two contracts. One with the buyer and CCP and the other with seller and CCP. Then net positions of the clearing members against the CCP are calculated. For securities, these net positions are posted as DVP settlement instructions to the CSD and settlement finalizes at the books of the CSD. In case CSD does not provide settlement for the cash leg of the transactions, other arrangements can be used in order to assure simultaneous transfer of securities and cash. [1]For derivatives, clearing members hold relevant collaterals to cover risks of their positions. At maturity, they fulfill their net cash obligations to the CCP by means of CCP's relevant payment arrangements. In case of physical settlement of the contracts, CCP initiates DVP settlement instructions to the CSD if the underlying is a security.

[1] As a special case, CCP incorporates securities settlement system (SSS) in Turkey. CCP's SSS assures simultaneous movement of cash in its own books (as it is also a bank) and securities in the books of the CSD. In general, CSD is the securities depository and incorporates SSS.

For other asset types as underlying, physical settlement instructions are sent to the relevant institution depending on the asset type.

CCP risk management mechanism includes default funds and collateral management. CCPs collect default (or guarantee) fund contributions from each clearing member. In addition, CCPs calculate collateral requirement based on open positions and net positions of the clearing members. Initial margins are posted with respect to initial position and these margins are marked to market periodically, mostly more than once a day. Collaterals, default fund contributions and CCP's own capital are used in order to cover positions of any clearing member in default. The usage of the sources in case of default is determined by the default waterfall mechanism and other relevant policies of the CCP. In the event of default, CCP compensates the relevant counterparties so that default of one party does not cause chain defaults in the market. Position limits and other risk control mechanisms based on pre-trade orders, trade executions are also available on top of post trade risk management. These risk management facilitates can be provided by the exchange or the CCP, or by both in conjunction.

CCP clearing has become mandatory after 2008 financial crises, in Europe, US and other parts of the world. CCP landscape is highly regulated and oversight by the public authorities.

2.2.3 CSDs

Securities are deposited to the CSDs by the issuers. This is also called notary service, as it is the initial recording of the securities in a book entry system. Securities deposited at the CSD can be transferred to the safekeeping accounts of the investors at the CSD books. This function of CSDs is referred as maintaining securities accounts at top tier level in European context. The system that manages the transfer of securities among CSD accounts is called Securities Settlement System (SSS). Depository, safekeeping and settlement are regarded as core CSD services. In most cases, they are jointly provided by one entity. Corporate actions processing, information processing services on tax and general meetings as well as collateral management, securities lending mechanisms, regulatory reporting, and services provided to registrars, issuers or their transfer agents are ancillary CSD services.

CSDs hold securities in physical, global certificate or dematerialized forms. Securities safekept at CSDs are traditionally in the form of physical certificates that represent the legal ownership of the account holders for which they are safekept by the CSD. Global certificates are created to reduce cost of printing and keeping all the share certificates physically. A global certificate is one piece of certificate that represent the collective ownership of all shares in the books of the CSD. Each CSD account holder owns a proportion of the global certificate in line with its balance. Dematerialized securities are fully-electronic securities created on the books of the CSDs. Today, physical form securities are rarely used. Global certificates are still in use, especially in Eurobonds, government securities and some other securities. Dematerialized securities are widely accepted. Dematerialization is enforced by most of the regulations around the world. Most of the securities are safekept on fungible basis in bearer form. Registered securities, in which holder names are an integral part of the securities, are rarely available.

Settlement is the transfer of securities among the CSD accounts. There are two types of settlement arrangements: free of payment (FOP) settlement and delivery versus payment (DVP) settlement. FOP settlement is direct one-way transfer of securities from one CSD account to another. DVP settlement is simultaneous transfer of securities and related cash between the parties. In DVP settlement, securities are transferred in the CSD books; cash may be transferred in the CSD, central bank or commercial bank accounts depending on the CSD's payment model. Settlement in central bank money indicates that cash side of the transactions is directly posted and realized on the central bank accounts. Settlement in commercial bank money indicates that cash side of the transactions is fulfilled by commercial banks. Commercial banks include the CSD itself and other settlement banks. If CSD itself is also a bank, then it manages both securities cash positions, and achieve true real time DVP. If the commercial banks are used as settlement banks, CSDs maintain arrangements with the settlement banks to manage cash flows[1].

CSD members are custodians or brokers. Custodians provide custody services to their clients. Brokers safekeep proceeds from trades that they executed, cleared and settled in the name of their clients. In countries where nominee concept is recognized, legal ownership and beneficial ownership concepts are identified. The custodians or brokers hold their clients' securities at the CSD collectively in one account. These accounts are called omnibus accounts. In these countries, after the broker settles the trade, the securities are usually transferred to a custodian account. The custodians keep client details of the securities. Therefore, this type of safekeeping is also called tiered booking system and CSD accounts are regarded as top tier accounts. Custodian banks provide downstream custody services such as corporate actions, tax, general meeting and proxy voting services. This account structure is applied in developed markets in general. In countries where nominee concept is not recognized, distinction of legal and beneficial owner is not identified. Therefore, anybody holding the securities in the CSD account is both legal and beneficial owner of that security. In these CSDs, CSD members record the securities in segregated investor accounts. All investors can be identified in the books of the CSDs. In most emerging markets, CSD accounts are segregated at investor level.

International Central Securities Depositories (ICSDs) provide CSD services for international securities that has no domicile country. Most widely known international security type is “Eurobond”. ICSDs also provide global custodian banking services through their account links in various local CSDs. They have banking license and provide cash transfer and foreign exchange services as well. Global custody services are provided by large global banks. These banks have account network in various local CSDs worldwide. Global custodian banks provide settlement and custody services in various markets. ICSDs combine CSD and global custody services.

2.3 Business Integration and Product Diversification

CMIs are traditionally regulated monopolies at national or market level. They accumulate the liquidity in the market. However, technological improvements made remote access possible. In addition, competition became an issue in the industry. Alternative trading venues challenged the monopoly position of the exchanges globally. New clearing houses that serve the alternative trading venues also challenged the existing ones. All these caused conventional monopolies to lose their market power and opened way to competition locally and globally. Consequently, transaction fees were reduced. Regulators focus on establishing a competitive market design; so that commissions that end investors pay for transaction processing, is reduced to competitive level. Meanwhile, in the last two decades CMI industry have faced various types of integrations, diversification of activities and consolidation at national, regional and global scale. These integrations and consolidations do usually take place in form of mergers and acquisitions in developed markets, country level restructurings arranged by regulatory changes in emerging markets.

2.3.1 Business integration models

Horizontal integration is merger or consolidation of trading platforms, clearing and CCP services or SSSs. Vertical integration is consolidation of the capital market infrastructure value chain. Vertically integrated exchanges extend their services to post trade. Vertical integration can be in the form of exchange and CCP integration or integration of whole value chain. Multiway integration includes integration at horizontal and vertical dimensions. Horizontal, vertical and multiway integration is depicted in of Figure 2.2.

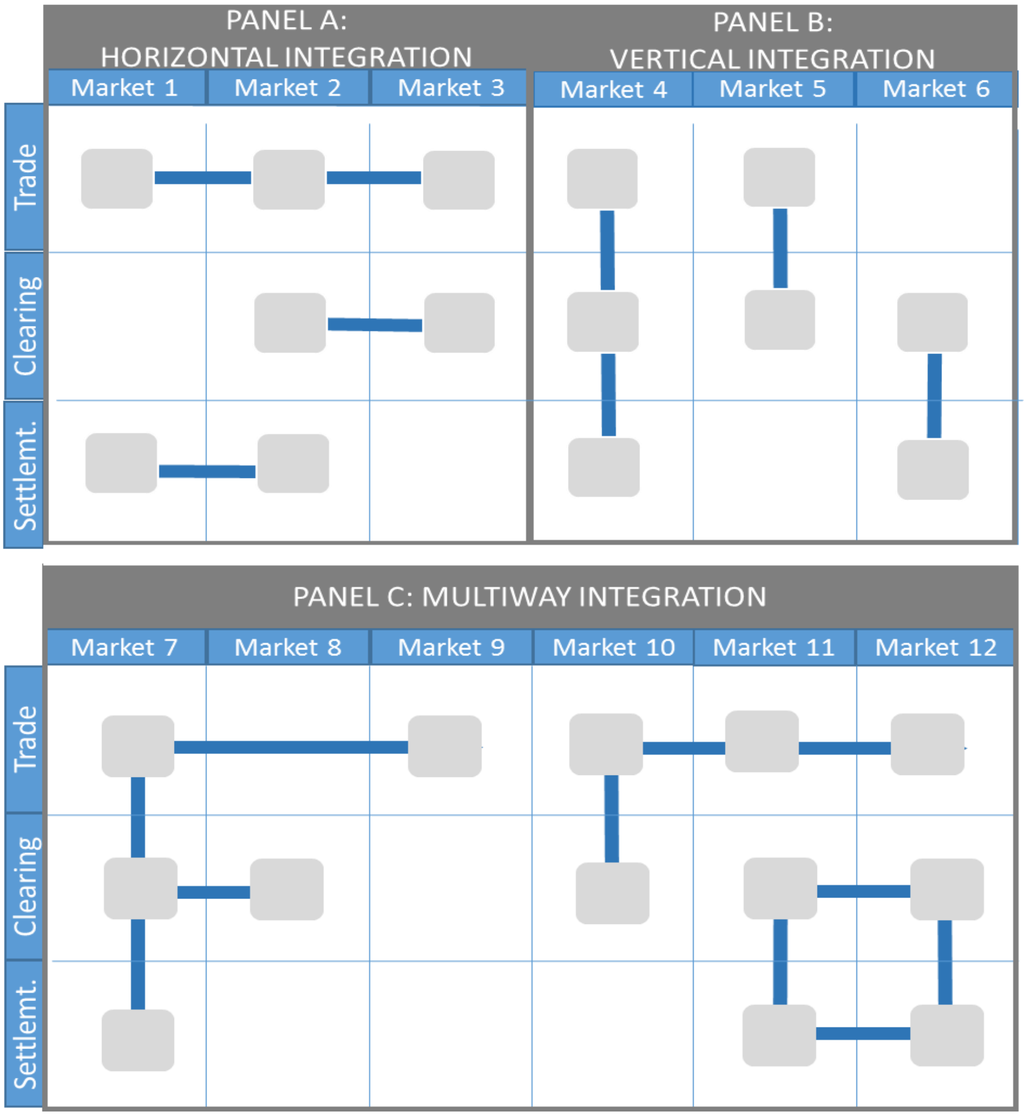


Figure 2.2 : Horizontal, vertical and multiway integration.

Horizontal integration can take place in the form of mergers or acquisitions among exchanges, CCPs or CSDs (Panel A). Exchanges can vertically integrate by acquiring or organically growing CCP or CCP and CSD services. Vertical integration can also take place between CCPs and CSDs. Examples are depicted in Panel B of Figure 2.2. Multiway integration incorporates mergers and acquisitions both in horizontal and vertical levels, some examples are depicted in Panel C of Figure 2.2.

2.3.2 Product diversification

Product diversification is providing platforms for multiple asset classes, such as securities and derivatives for exchanges and CCPs. In addition, value added data and information services and information technology (IT) services are also diversification methods used by exchanges recently. Product diversification opportunities for exchanges and CCPs are depicted in Figure 2.3 (Panel A). For CSDs, ICSD services are product diversification since these include combination of CSD and global custodian bank services. Services included in ICSD diversification are depicted in Figure 2.4 (Panel B). These include CSD services for international securities, regular banking services such as cash transfer and foreign exchange conversion as well as account links to local markets where global custody services are provided.

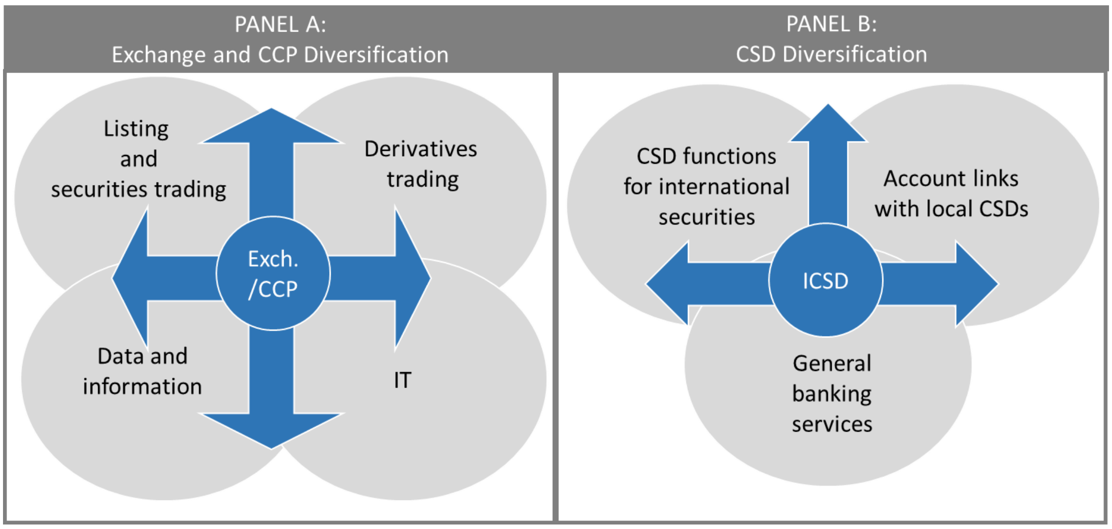


Figure 2.3 : Product diversification in exchanges, CCPs and CSDs.

2.4 Other Market Linkage Strategies

Business integration and diversification includes full integration in the infrastructure value chain or diverse business units in terms of management, reporting and corporate body. However, various other ways of cooperation and linkage are also available. Remote access, interoperability or CSD linkages provide bridges among markets and make local markets more accessible for foreign participation. Multi listing is another way of accessing remote market investors for the issuers. We provide a detailed description of linkage models in the primary and secondary markets in order to provide background for the current global landscape.

2.4.1 Linkage of secondary markets: Remote access, interoperability and CSD linkage models

Investing at home market is straightforward. Traders have direct access to exchanges or other trading venues in home market. They have clearing and custody arrangements with local intermediaries. In remote markets, setting up arrangements with local trade, clearing custodian intermediaries and passing transactions through them is the most conventional way of market access for investors. However, it is costly. Therefore, linkage of CMIs in different markets are facilitated. Remote access to trading venues, CCP interoperability and CSD links are means of linkage in the capital market infrastructure value chain.

Remote access through market connectivity technologies enables traders to reach the exchanges' trading platforms remotely. Examples of remote connectivity models are presented in Figure 2.4. Connectivity technologies allow trading members to access the exchanges' trading platforms through network service providers. This kind of technologies have various usages. It allows smaller trading participants to connect to the exchange through intermediary technologies in a more cost-effective way. It also allows trading members in remote locations, where they cannot directly connect the exchange systems, to access the trading platform of the exchanges.

Market connectivity technologies can be used by the two exchanges whose members will be able to trade in both exchanges. In this case, trading members of one exchange should be accepted as trading member in the other exchange. Therefore, market connectivity projects between exchanges may require extension of trading member profile to foreign markets or jurisdictions. Especially, if the two exchange operate under different jurisdictions, the regulators could prohibit acceptance of remote members from a foreign country/jurisdiction. In Europe especially, remote access is enforced by the regulations as it is a feature of connecting all national markets virtually within European Union (EU).

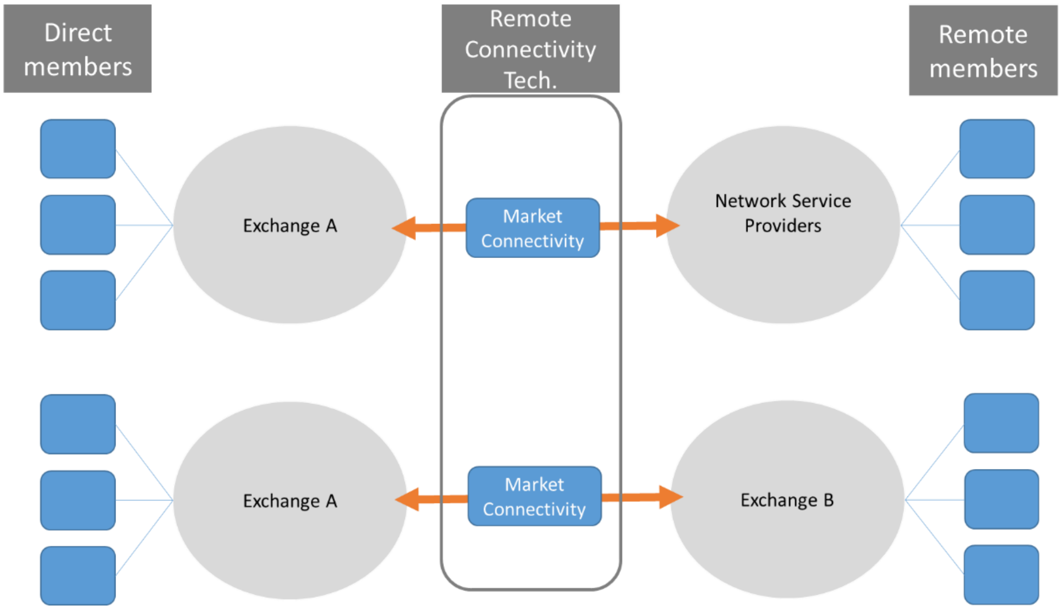


Figure 2.4 : Market connectivity and remote membership.

Interoperability links between CCPs are widely used in order to reduce margin requirements and clearing costs when trading in various markets. It allows traders and clearers to net intra market positions. Therefore, we can say that interoperability of CCPs and remote access to the trading venues complete each other. With interoperable CCPs, traders become able to clear their trades in remote markets through their local CCP, they do not need to make any further membership agreement with CCP that provides clearing in the remote trading venue. Interoperability allows accumulation of liquidity for the trade and clearing participants.

Two main types of interoperability links are depicted in Figure 2.5. In participant model (Panel A), one CCP becomes clearing member of the other. The CCP that maintain link to the trading venue is the host CCP, the CCP that become clearing member in the host CCP is the participant CCP. Participant CCP is obliged with guarantee fund contribution and margin requirements as well as other clearing members. Peer to peer interoperability (Panel B), on the other side, allows the two interoperable CCPs to clear the net positions of each other. In peer to peer model, CCPs do not contribute to each other's guarantee funds and provide margin requirements as net of all CCP positions at each other.

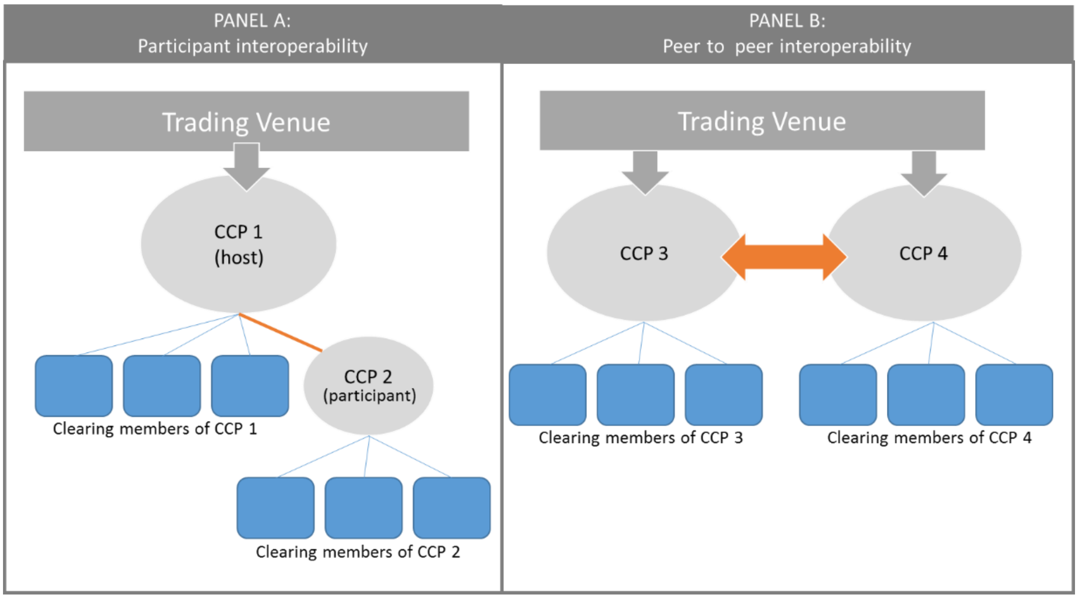


Figure 2.5 : CCP interoperability.

In capital markets transaction lifecycle, the last chain is the settlement and safekeeping of securities that are traded and cleared. This could be achieved by selecting a custodian that would provide settlement and safekeeping services in remote market or through a CSD linkage. Possible CSD linkages are depicted in Figure 2.6. Investor CSD is the CSD that would hold securities which are issued in the other CSD (issuer CSD). In indirect linkage model (Panel A), investor CSD uses a member of issuer CSD as intermediary. In direct linkage model (Panel B), investor CSD opens an account at the issuer CSD. The direct or indirect linkages could be one-way or reciprocal. A CSD could be issuer CSD for the securities deposited in itself and investor CSD for the securities deposited in other CSDs.

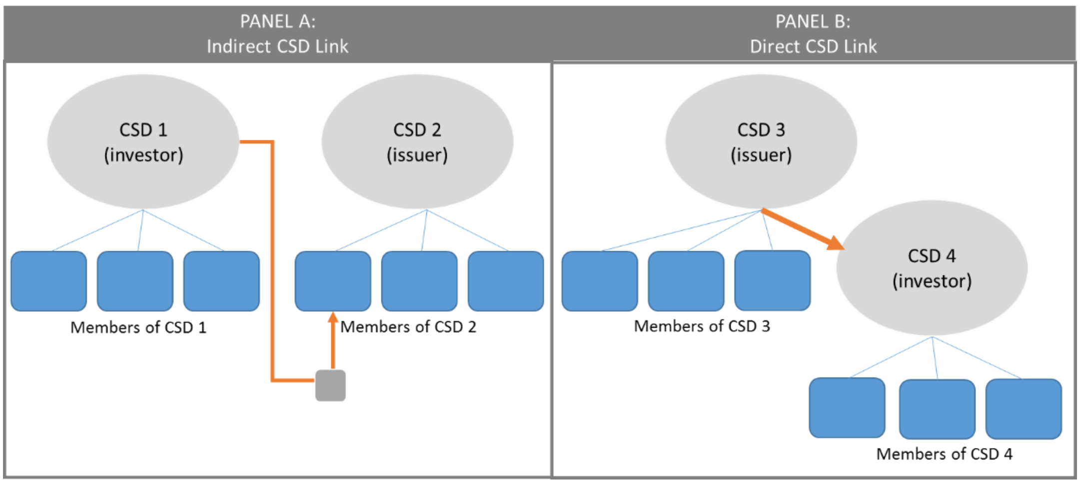


Figure 2.6 : CSD links.

2.4.2 Remote access in primary markets: Multi-listing and multi-depositing

In secondary market linkage models, the focus is to bring remote market investors virtually to the markets where securities are domiciled. On the other side, issuers may also seek to expand to remote markets by issuing securities there. In this case, investors in remote markets can trade these securities with their local trade and post trade setup in place. However, regulations regarding securities issuance in remote markets are more restricted and complicated. Legislations regarding securities issuance is locally bounded more strictly. Therefore, we can say that access to remote markets is more complicated for issuers than for investors.

Listing and issuance of securities in remote markets is depicted in Figure 2.7. Equities (Panel A) listed and deposited in remote market are also listed and deposited in their home country markets as well. Therefore, these securities are called multi- listed or multi-deposited securities. Listing equity in a remote exchange requires issuance of the securities in the remote CSD s as well. It is technically possible to list a security in a remote exchange and still use the local CSD. However, objective of multi listing is to fully localize the security for investors in the remote market. Thus, multi listing is applied together with multi depositing. Issuance of equities in the remote CSD can be in two forms. The securities to be settled among remote market investors can be transferred to the remote CSD's (CSD-B) accounts at the home CSD (CSD-A) books. Then the remote CSD makes these securities available for settlement in its own books. For this method, remote CSD (CSD-B) should establish direct or indirect CSD link to home CSD (CSD-A). In this case, CSD in the home country of the security (CSD-A) has the issuer CSD role, and CSD in the remote market (CSD-B) is the investor CSD role. This method is referred as direct deposit. Direct deposit method became available as the CSDs began to establish direct CSD to CSD links. Secondly, and more traditionally, multi listing and deposits are processed with depository receipt method. In this method, a custodian bank domiciled in the remote market (custody bank B), keeps the securities at an account in the securities domicile country. In most cases this account is an account under a custodian member of the home CSD (custody bank A). Then, this custodian bank domiciled in the remote market (custody bank B) issues certificates in the remote market that represents the shares safekept in the home market. With this mechanism, shares are deposited in multiple CSDs. At the listing side, the issuer company should fulfill each exchange's listing requirements and procedures exclusively. Direct-deposited shares can be realigned between the CSDs. New depository receipts can be created or available depository receipts can be converted to the original shares upon the market demand for the security in the remote market.

For bonds on the other side, listing is usually not required due to the OTC nature of bond trades. Issuance at the CSD of the remote market is straightforward, provided that the issuer fulfils the regulatory requirements for issuance in the remote market. Bonds can be deposited exclusively in the remote CSD (Panel B) as well.

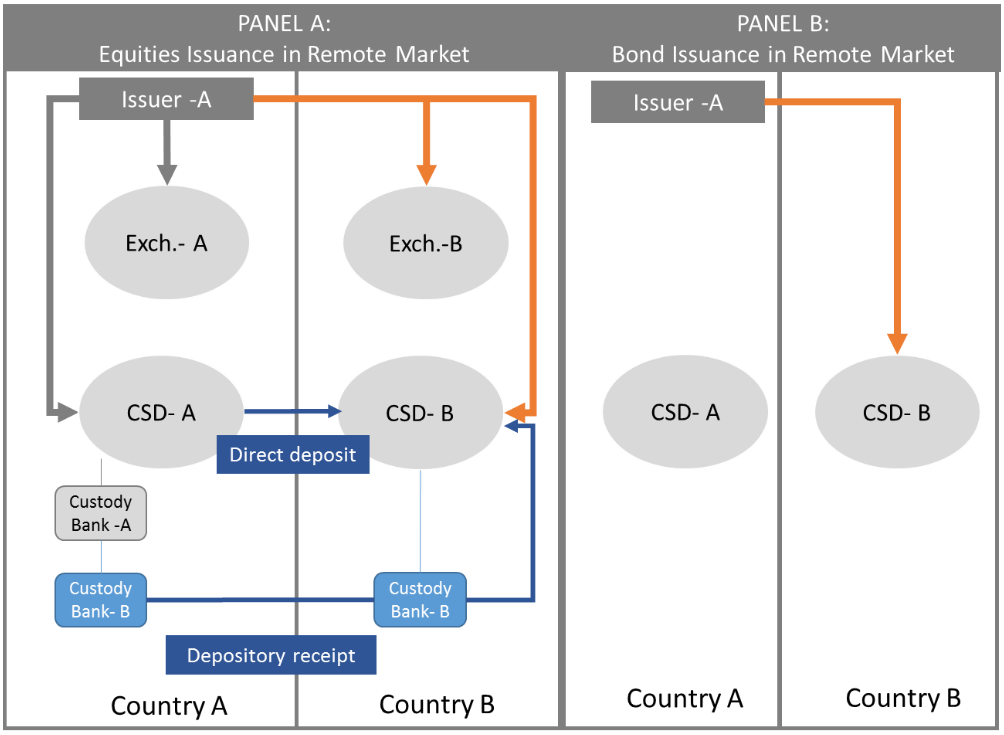


Figure 2.7 : Securities listing and issuance in remote markets.

2.5 Conclusion and Remarks

In this chapter, we try to introduce the basic concepts regarding the capital market infrastructures. We define the value chain and various types of strategic interactions. These strategic interactions include business integration models and product diversification as well as linkage strategies at each level of the value chain. These concepts are very important to understand the functioning of the industry as well as the evolution of the market structure. In the following chapters, we will further discuss the integration, diversification and linkage models in terms of global and regional inclinations and welfare effects.

3. CAPITAL MARKET INFRASTRUCTURE LANDSCAPE: GLOBAL OUTLOOK

3.1 Introduction

CMIs were initially regional or national. Today, these infrastructures are reducing in number but growing in size. Diversification in terms of asset classes served, backward integration in the value chain or horizontal mergers are the main drivers of the consolidation in the industry. Today, limited number of entities are competing to be global sector leaders. This chapter pronounces general overview of the CMIs globally. The information provided here is accurate up to end of 2018. Figure 3.1 is a snapshot of the global landscape, which is explained in detail throughout the chapter.

Today most CMIs are profit oriented private companies. Demutualization process has been globally completed. Many CMIs are listed, or in IPO process. For derivatives, CCP business is mostly integrated with trading. CCPs and CSDs that are not integral part of exchanges pursue their existence by horizontally integrating clearing and CSD functions for multiple exchanges or trading venues. In some instances, public utility model is accepted for post-trade infrastructures (Lees, 2012), such as OCC and DTCC in the US, T2S in Europe and JASDEC in Japan. In other cases competition set forefront, as in the case of European clearing houses.

In the US and Europe, business integrations in horizontal, vertical and both ways are available. In emerging markets on the other side, nation level vertical integrations are predominant. World total market capitalization increases over time and emerging markets have higher share in the increase. Innovation and growth is higher in derivatives exchanges compared to securities exchanges (Geranio, 2016).

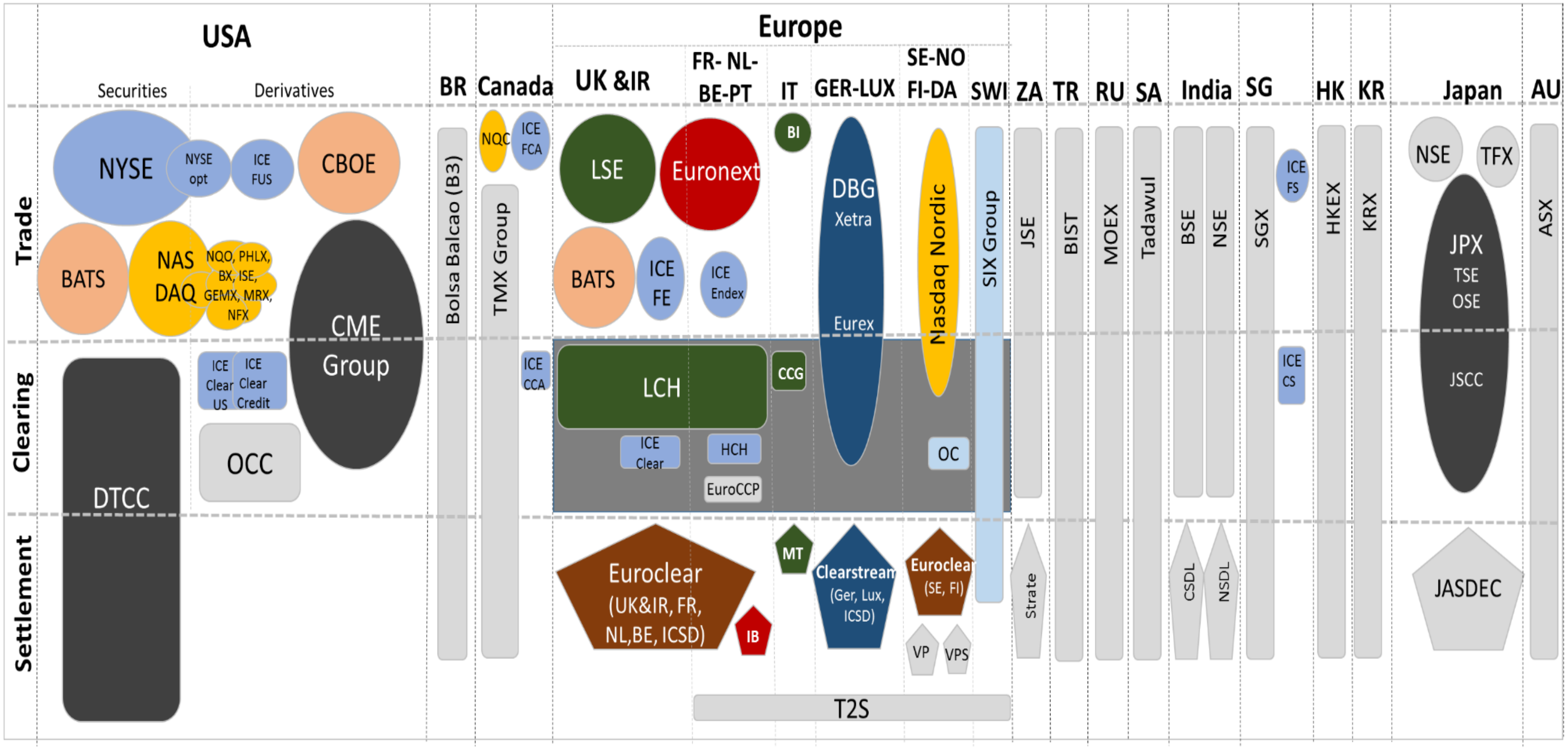


Figure 3.1 : CMI landscape worldwide.

Notes: [1] ICE Group (blue color) includes NYSE: New York Stock Exchange(includes NYSE, NYSE Bonds, NYSE American, NYSE Arca, NYSE National), NYSE Opt.: NYSE Equities Options Markets (NYSE Amex Options and NYSE Arca Options); ICE FUS: ICE Futures US, ICE FCA: ICE Futures Canada, ICE FE: ICE Futures Europe (former LIFFE), ICE Endex: Energy Exchange based in Amsterdam, ICE FS: ICE Futures Singapore (former Singapore Mercantile Exchange SMX); clearing houses ICE Clear US, ICE Clear Credit, ICE CCA: ICE Clear Canada, ICE Clear Europe, and Holland Clearing House (HCH). Group also have OTC trading platforms which are not mentioned in the figure (Creditex US and UK, ICE Swap Trade, ICE US OTC Commodity Markets, ICE Credit Trade, BondPoint). [2] Nasdaq Inc. (yellow color) includes three exchanges under NASDAQ (Nasdaq Stock Market, Nasdaq BX, Nasdaq PSX); six options exchanges NQO: Nasdaq Options Market, Nasdaq PHLX, Nasdaq BX, Nasdaq ISE, Nasdaq GEMX, Nasdaq MRX; an energy derivatives market Nasdaq NFX; and a fixed income trading platform Nasdaq Fixed Income US in the US. In Canada it operates a equities trading platform NQC: Nasdaq Canada (former Chi-X Canada). NQNM: Nasdaq Nordic Market operates in Sweden, Denmark, Finland and Iceland has market sections for equities, fixed income, commodities and derivatives. Nasdaq Oslo ASAis the commodity derivatives exchange for European products and freight in Norway. (The group also operates Baltic exchanges (Nasdaq Baltic) and Baltic and Iceland CSDs, these are not available in the figure.) [3] CME Group provides trading and clearing infrastructure for derivatives and includes CME (Chicago Mercantile Exchange), CBOT (Board of Trade City of Chicago), NYMEX (New York Mercantile Exchange), COMEX (New York Commodity Exchange), GEM (Growth and Emerging Markets), IMM (International Monetary Market), IOM (Index and Option Market).[4] CBOE Global Markets (pink color) includes derivatives markets CBOE (CBOE Options- former Chicago Board Options Exchange, C2, BZX and EDGX, CFE) and equities markets BATS Global Markets (BZX, BYX, EDGX and EDGA) in the US region. Cboe Europe Equities and Cboe Chi-X Europe (BATS) are pan European equities trading venues located in the UK. [5] DTCC (Depository Trust and Clearing Corporation) provides clearing and settlement for securities, OCC (Options Clearing Corporation) provides clearing for derivatives in the US market. In the US market securities and derivatives exchanges are separately presented as the distinction is clear. [6] In Brazil (BR), B3 (Bolsa Balcao-former BmfBovespa) is the sole infrastructure provider. [7] In Canada, TMX Group operates Toronto Stock Exchange and Montreal Exchange as well as Canadian Derivatives Clearing Corporation and Canadian Depository for Securities. [8] Institutions from UK, Ireland (IR), France (FR), he Netherlands (NL), Belgium (BE), Portugal (PT), Italy (IT), Germany (GER), Luxembourg (Lux), Sweden (SE), Norway (NO), Finland (FI), Denmark (DA), Switzerland (SWI) are presented in European market. [9] LSEG (London Stock Exchange Group) includes LSE (London Stock Exchange), LCH, BI (Borsa Italiana) , CCG (Italian clearing house) and Monte Titoli (Italian CSD). [10] Euronext operates exchanges of France (Paris), Netherlands (Amsterdam), Belgium (Brussels) and Portugal (PT), it also operates IB (Interbolsa), CSD of Portugal. It also operates Euronext London and Irish Stock Exchange (Euronext Ireland). [11] Euroclear Group (dark red color) operates CSD of UK, Ireland, France, Netherlands, Belgium, Sweden, Finland as well as the ICSD (Euroclear Bank). [12] Deutsche Börse Group (DBG- dark blue) includes Xetra (Frankfurt Stock Exchange), Eurex (derivatives exchange and clearing house), Clearstream (CSD of Germany, CSD of Luxemburg, and the ICSD, Clearstream Banking Luxemburg). [13] SIX Group of Switzerland operates Swiss Exchange, SIX x-Clear and SIX SIS (CSD) and Oslo Clearing (OC- SIX x-clear Norwegian Branch). [14] EuroCCP is pan European equities clearing house located in the Netherlands. [15] VPS is the Norwegian CSD and VP is the Danish CSD. [16] T2S (Target 2 for Securities) is the European Central Bank’s post trade platform for securities settlement in European Union. [17] In South Africa (ZA), JSE (Johannesburg Stock Exchange) incorporates exchange and clearing infrastructures, Strate is the CSD. [18] In Turkey (TR) BIST (Borsa Istanbul Group), in Russia (RU) MOEX (Moscow Exchange Group) in Saudi Arabia (SA) Tadawul consolidates trade, clearing and settlement infrastructures. [19] In India, BSE (Bombay Stock Exchange) and NSE (National Stock Exchange) consolidates trade and clearing infrastructures. NSLD (National Securities Limited Depository) and CSDL(Central Securities Depository Limited)are CSDs. In Singapore (SG) SGX (Singapore Exchange), in Hong Kong (HK) HKEX (Hong Kong Stock Exchange) and in Kore (KR) Korea Exchange (KRX) consolidate trading, clearing and settlement infrastructures. [20] In Japan, JPX (Japan Exchange Group) includes TSE (Tokyo Stock Exchange), OSE (Osaka Exchange) and JSCC (Japan Securities Clearing Corporation). NSE (Nagoya Stock Exchange) and TFX (Tokyo Financial Exchange) are other equities and derivatives exchanges in Japan. JASDEC (Japan Securities Depository Corporation) is the CSD. In Australia (AU), ASX (Australian Stock Exchange) consolidates trading, clearing and settlement infrastructures. [21] The information provided is accurate up to the end of 2018.

Figure 3.1 (continued): CMI landscape worldwide.

3.2 US and Europe

US originated global CMIs are ICE Group, Nasdaq, CME Group and CBOE Global Markets. ICE Group, Nasdaq and CBOE Global Markets have geographical presence in US and Europe, while, CME Group remains only US domiciled with global client profiles. CME Group winded down its presence in Europe and consolidated all activities in US in 2017. CBOE and ICE have MTFs in Europe. Nasdaq operates various regulated exchanges worldwide, only in the US and Europe. OCC (Options Clearing Corporation) and DTCC (Depository Trust and Clearing Corporation) are the two US post trade service providers. In the US, many exchange infrastructures are available and they operate in competition. Post trade infrastructures have public utility model. They are strictly regulated and consolidated. All securities post trade services are provided by DTCC. Derivatives clearing services can be provided by the exchanges themselves or by OCC.

LSEG (London Stock Exchange Group) and DBG (Deutsche Börse Group) are the two European exchange leaders that have operations worldwide. They both have trade and post trade services. Euronext is a pan European exchange. LCH of LSEG, Eurex and Clearstream of DBG, Euroclear Group and EuroCCP provides post trade services for the European market. Europe has fragmented market structure for both trade and post trade services. Remote access, interoperability and account links are enforced by the regulators. The aim is to maintain competition in the market. For the trade side, remote access is applied; so that investors and intermediaries are free to access any exchange or MTF across Europe. On the clearing and CCP side, all major CCPs (EuroCCP, LCH, CCG, and SIX x-clear) have interoperability links. These links are only for securities and securitized instruments clearing. For derivatives, the only link is between LCH and SIX x-Clear Norwegian Brach. CCPs are able to provide services to pan European client base for pan European securities. For derivatives, CCP links are not common. For example, Eurex is the major derivatives exchange with pan European client base. It has both trade execution and clearing facilities. In addition, Nordic derivatives markets as well as ICE markets also have pan European access. For these, derivatives trading and clearing are also accomplished by the exchange or exchanges' CCP subsidiary. Therefore, we can assume that competition among the derivatives exchanges is in the form of pan European access, rather than CCP interoperability. Bilateral CSD links are available, however, due to the strict national regulations on securities issuance and corporate actions, a full harmonization could not be achieved. Together with new CSD Regulation (2014), “Target 2 for Securities” project initiated by European Union (EU) and European Central Bank in order to achieve harmonized market practices in settlement operations across Europe. EU also aims to harmonize the depository and corporate actions landscape in order to achieve ‘one efficient market’, still national borders are strong in this line of infrastructure.

3.3 Rest of the World

3.3.1 Developed markets

TMX Group in Canada, SIX Group in Switzerland (Europe), Australian Stock Exchange (ASX), and Hong Kong Stock Exchange (HKEX) provide trade and post trade services for multiple asset classes. In these markets nation level consolidation is vertically in the value chain, in addition asset class differentiation is available. These CMIs have attempts to grow regionally. For example, TMX Group has some activities in the US, however, the main focus is the Canadian market. HKEX acquisition of London Metals Exchange (LME) in 2012 is an attempt to geographical and business line diversification. In 2018, 15 % of HKEX revenues come from UK based activities due to LME. Still, HKEX has local focus. SIX Group of Switzerland has European wide payment and information services, however, considering exchange and post trade services, it is still regarded as national silo with attempts to grow multiway (i.e. acquisition of Norwegian clearing house).

Japan and South Africa exchanges are integrated with the CCP. Japan Exchange Group (JPX) consolidates Tokyo and Osaka market places in trading and clearing activities. As this includes integration of market places as well as trade execution and clearing/CCP functions, JPX can be regarded as multiway integrated. Japan CSD JASDEC is horizontally integrated and serves for multiple regulated markets and alternative trading venues. Tokyo Financial Exchange (TFX) also integrated trading and clearing. Nagoya Stock Exchange (NSE) is an independent securities exchange, trades on NSE is cleared by JPX’s clearing subsidiary. In South Africa, Johannesburg Stock Exchange (JSE) provides clearing and CCP services integrated with the exchange infrastructure. Strate is the depository and provides settlement services for multiple market places within the country.

3.3.2 Emerging markets

Brasil Bolsa Balcao (B3- former BmfBovespa), Moscow Exchange Group (MOEX), Borsa Istanbul (BIST), Korea Exchange (KRX), Singapore Exchange (SGX) and Tadawul in Saudi Arabia provide trade and post trade services for multiple asset classes. In these markets, consolidation is vertically in the value chain at national level, in addition asset class differentiation is available (except Tadawul).

In India exchanges are integrated with the CCP. Still exchanges have strong relations and links with the CSD, even though CSDs are independent in management and financial reporting. National Stock Exchange (NSE) of India provide clearing and CCP services integrated with the exchange infrastructure. Bombay Stock Exchange (BSE) has previously consolidated whole value chain, however, in 2017 it also demerged the CSD. Currently National Securities Depository Limited (NSDL) and Central Securities Depository Limited (CSDL) provide CSD services in India. India depicts a special case where two vertically integrated exchanges and associated CSDs operate under same jurisdiction.

3.4 Market Types: Fragmentation and Beneficial Ownership Models

Brazil, India, Korea, Russia, Singapore, Saudi Arabia and Turkey are beneficial owner basis markets, in which investor level segregation is required at trading, settlement and custody. In these countries, trade orders are accepted to exchanges in the name of investors and securities are settled in CSD accounts in the name of the investors (beneficial owners). Distinction between legal and beneficial ownership is not recognized in the legislations. In other markets, trades are processed in the exchange platforms without investor detail and securities are safekept at omnibus custody accounts at CSDs. CSD accounts are regarded as top tier accounts. Investor details are booked at lower tiers, i.e. in the CSD members' (custodians) own books.

In US, Europe, Canada, Australia, Japan, Hong Kong and Switzerland exchange business is fragmented; i.e. in these markets alternative trading venues are available. In South Africa alternative exchanges are allowed, some are in establishment stage, and trading volumes in these exchanges remain low. Nominee concept is recognized in the legislation; legal and beneficial owners are distinctive. CSDs hold top tier omnibus accounts, investor details remain in the books of the custodian intermediaries.

3.5 Regulatory Framework

Regulatory framework affects the integration opportunities and motives in the CMI industry. Before 2008 regulations in the US and Europe are associated with deregulation; the focus was primarily maintaining competition among the CMIs. Rules on order protection and transparency are adopted in the US under National Market System and in Europe under Markets in Financial Instruments Directive (MiFID). These regulations aim to impose best execution rule[2], transparency and market integration; consequently, competition in trade execution facilities.

After 2008, the focus changed to stability and integrity of the financial system on global scale. Therefore, after 2008 new rules and roles are imposed on the infrastructures. The new rules apply to all capital markets instruments, specifically OTC derivatives and financing instruments. They include execution, clearing and post trade reporting activities. Supervision and market surveillance are the new focus of the regulators. CMIs are obliged to provide reporting and other monitoring functions. Following the 2009 Pittsburg G-20 Summit, Financial Stability Board (FSB) is established in order to implement new reforms globally. FSB supports the global application of new principles such as trade repository reporting, mandatory CCP clearing and other market surveillance functions.

In the US, Dodd-Frank Wall Street Reform and Consumer Protection Act came into force in 2010. The new law aims to improve accountability and transparency of the financial firms, to end "too big to fail" and bailouts, to protect consumers from abusive financial services practices. Orderly Liquidation Authority is established to monitor the activities of big financial firms. Consumer Financial Protection Bureaus are established in order to protect consumers against abuses related to credit cards, mortgages, and other financial products. Financial Stability Oversight Council and the Office of Financial Research are established to identify threats to the financial stability. Federal Reserve is furnished by new roles to regulate systemically important institutions. The Volcker Rule restricts banks from making certain kinds of speculative investments. OTC derivatives instruments, which are exempt from regulation prior to 2008 crises, are regulated by the reform. Mandatory clearing by regulated exchanges

[2] Best execution rule imposes that trade intermediaries route the orders they receive from investors to the exchange or alternative trading venue that provides best price and lowest cost.

or clearing houses is imposed. In order to increase the transparency in the OTC derivatives trading, use of Swap Execution Facility (SEF) is mandatory. SEF is a platform that provides pre-trade information and trade execution. The law also imposes new rules on corporate governance, derivatives contracts and credit rating agencies.

In Europe, several new regulations came in force after 2008. In 2011, European Securities Market Authority (ESMA) is established in order to achieve investor protection, orderly markets and financial stability in European Union (EU). ESMA’s functions includes assessing risks to investors, markets and financial stability, completing a single rulebook for EU financial markets and promoting supervisory convergence across EU. ESMA is also the direct supervisor for credit rating agencies and trade repositories in EU. In 2012 and 2013, Basel 2 and Basel 3 criterias are imposed by European Market Infrastructure Regulation (EMIR). New requirements regarding stress-testing, liquidity, models, risk management, organization and governance are imposed on banks and financial firms. All financial instruments including OTC derivatives are required to be cleared by CCPs. All trading activity including OTC are reported to the trade repositories. The Regulation on markets in financial instruments (MiFIR) and the Directive on Markets in Financial Instruments (MiFID II) are accepted by the EU parliament and EU Commission in 2014 and became effective in 2018. MiFIR/ MiFID II sets out market conduct, investor protection, trading execution and reporting requirements for trading of financial instruments. With the new regulation, alternative trading venues such as dark pools are taken into scope of regulations. Dark pool trading is capped. New rules are imposed on firms that have algorithmic or high frequency trading. Trade reporting became mandatory for all financial instruments including commodity derivatives as well as all off exchange OTC trading. Vertically integrated clearing is abolished and non-discriminatory access is strictly imposed. New rules in order to improve investor protection are also in the scope of the regulation.

Securities Financing Transactions Regulation (SFTR) is accepted in 2016 and will be fully enforced until 2021. The regulation mandates reporting of all securities financing transactions including all types of repurchase, securities lending and margin lending transactions; so that the regulators can monitor and restrict reuse of securities as collateral for financing. CSD Regulation (CSDR) of EU entered into force in 2017, full compliance of CSDs to the regulation has been completed by 2019. All aspects will be implemented by 2023. CSDR brings about European level common standards for prudential, organizational, and conduct of business for CSDs. It harmonizes securities settlement operations and settlement discipline across EU. It also introduces new measures for the authorization and supervision CSDs across Europe. The objective is to design a competitive playing field for the CSDs across Europe.

In line with regulations in Europe and in the US, international organizations provide guidelines and implementation standards that guides the implementation of these regulations. Committee on Payments and Market Infrastructures and International Organization of Securities Commissions (CPMI-IOSCO) work together in Principles for Market Infrastructures (2012), which is the major standards guideline for all CMIs. Cyber by IOSCO (2016) provides guideline for cyber security and resilience, CCP Recovery and Resolution Planning by FSB (2016) for CCP risk management and resilience.

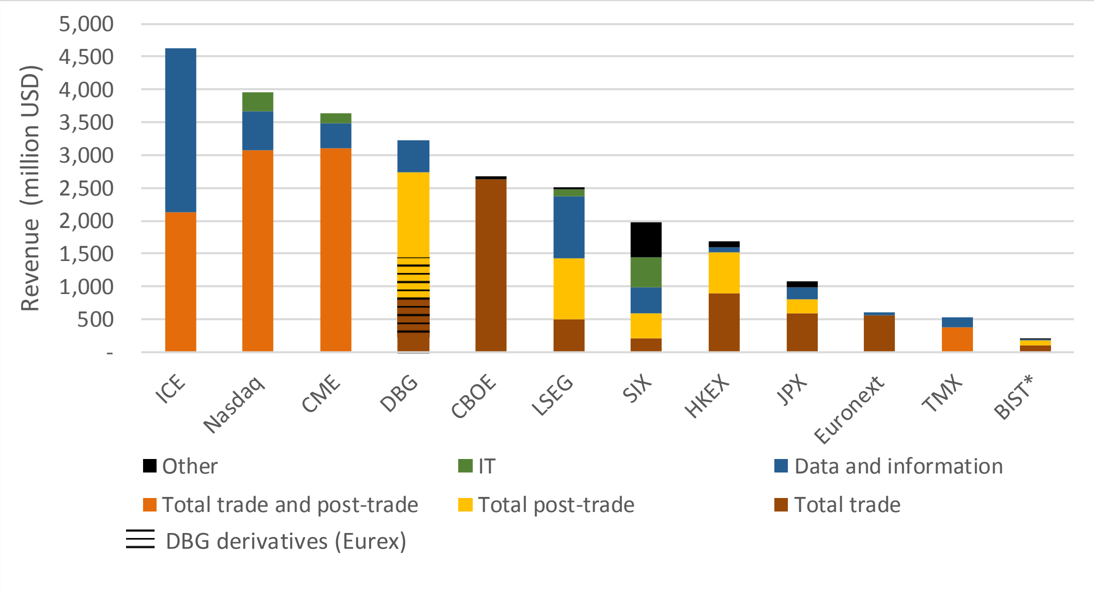
All other countries across the world reviewed their capital markets regulations and followed the regulatory trend of new rules. They also take the CPMI- IOSCO and FSB guidelines as benchmark for investor protection, market integrity and resilience.

The new regulations affect the functions of the CMIs. New roles on additional market surveillance and reporting facilities are adopted. Mandatory trade repository reporting and CCP clearing for OTC derivatives are some examples. With the new regulatory background, costs and technology requirements of CMIs have increased, consolidation became more predominant. Mandatory clearing made CCP business more attractive. Harmonization in the functioning of the capital markets increased due to global use of common standards. This leads to increased use remote access and interoperability links at global scale. Consequently, the sector became more competitive at global level.

3.6 Regional and Value Chain Integration Aspects

Due to technological improvements, demand for international trade and competition from alternative trading venues, exchanges in US and Europe are forced to find new ways to reduce costs and generate revenue. Global mergers and acquisitions that take place in the last two decades led to less number of CMIs, and emergence of sector leaders in developed markets. Emerging markets followed this trend by consolidating trade and post trade activities for multiple asset classes in their national borders. Cross border integrations are rare in emerging markets as national regulators have protective approach.

Breakdown of exchange revenues with respect to integration back in the value chain as well as diversification to data and information services as well as technology (IT) services is shown in Figure 3.2. Revenues from exchange business, namely listing and trading revenues are indicated as total trade revenues. Revenues from CCP and CSD business lines, namely clearing, risk management, settlement, custody, securities issuance fees are indicated as total post-trade revenues. In some cases trade and post-trade breakdown of the revenues could not be found. In this case total trade and post-trade revenues are shown.



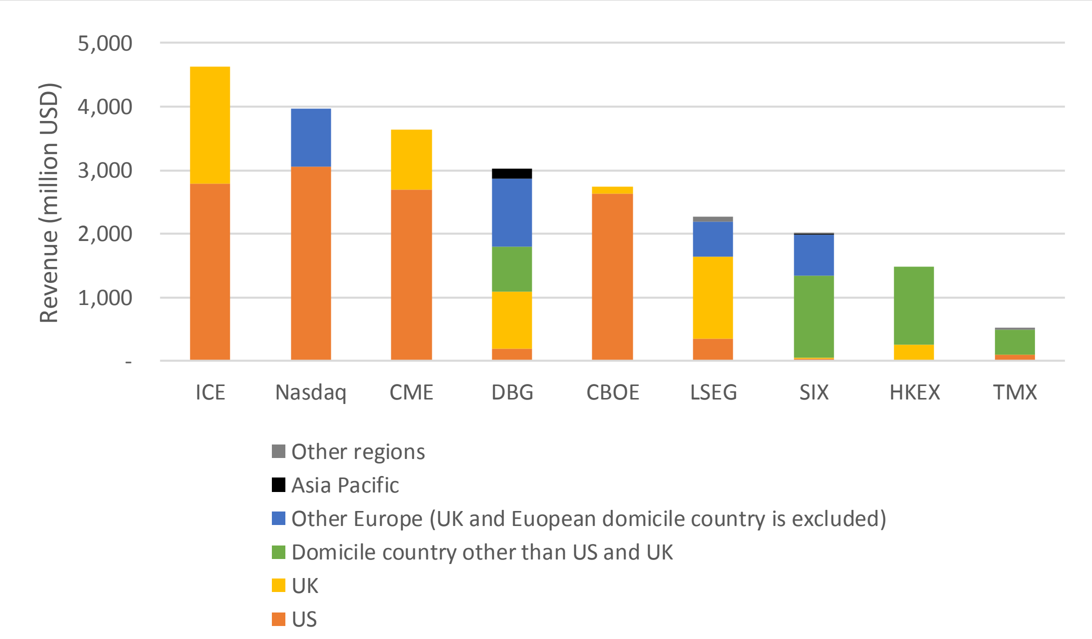
Notes: Revenues are operating revenues derived from companies' 2017 financial statements.
*Revenues for BIST excludes interest revenues due to banking activities.

Figure 3.2 : Revenue breakdown of exchange activities.

ICE and LSEG have highest share of data and information services revenue compared to their total revenues. For ICE, Nasdaq and CME decomposition of trading and clearing fees could not be obtained. We see that DBG and LSEG which are both multiway integrated have higher post trade revenues than trade revenues. These CMIs own the major two CCPs of Europe, namely Eurex Clearing and LCH respectively. Among national silos, HKEX of Hong Kong and BIST of Turkey also have relatively high post trade revenues. All these explain the attempts of exchanges in the developed and emerging markets to integrate back in the value chain. In Japan, post trade fees include only clearing fees and made up almost half as much as trading fees.

Regional dispersion of selected exchanges in terms of revenues generation is presented in Figure 3.3. Among the US originated CMIs, ICE has the highest European coverage.

Nasdaq, CME Group and CBOE follows. ICE, CME Group and CBOE maintains their European access with their subsidiaries in the UK. Nasdaq on the other side owns Scandinavian and Baltic CMIs. DBG and LSEG have some presence in the US, however they are mainly European. HKEX and TMX have mainly home country focus. HKEX have activities in the UK through LME and TMX have some derivatives exchanges in the US.



Notes: Revenues are operating revenues derived from companies' 2017 financial statements.

Figure 3.3 : Revenue breakdown of exchange geographical dispersion.

US and Europe originated CMIs utilize both geographical and business line diversification at highest level. Emerging markets use product diversification; however, their regional exposure is limited to national borders.

3.7 Demutualization: Setting path to mergers and acquisitions

Most of the CMIs are demutualized today. The early demutualization events took place in 1990s; and fully completed in the developed markets by the early 2000s. Stockholm Stock Exchange is the first demutualized exchange (1993). With the demutualization process, exchanges are transformed from dealer's club to for profit organizations. Then a wave of public listing began. ASX is the first exchange that went public by listing in its own exchange (1998).

Demutualization is verified to have increased exchange performance in the short and long run. Hart and Moore (1996) provides an initial comprehensive analysis. Mendiola and O'Hara (2004), Aggarwal and Dahiya (2006), Otchere (2006) and Azzam (2010) are some examples that provide empirical evidence for increased performance of exchanges after demutualization. Recently, Geranio (2016) provides a detailed description and aspects of demutualization on exchange performance. Another recent study also reveals that corporate governance procedures applied following the demutualization plays a key role in increasing the performance of the exchanges. The exchanges benefit from demutualization the most if they have a diversified board, fewer members and more directors with specific competences and experiences (Slimanea and Angulob, 2018).

Following the demutualization, profit orientation as well as competitive pressures from the new technology rivals (alternative trading venues) gave rise to merger and acquisitions in the industry.

3.8 History of Mergers and Major Merger Waves

After the wave of demutualization and privatization of the CMIs during the 1990s, mergers with specific patterns became predominant in 2000s. The motives and patterns that construct the major merger waves can be summarized in eight groups. First wave of mergers are pooling mergers in which same type of transactions are consolidated in order to reach higher scale in operations. This is followed by acquisition of competitor alternative trade execution venues. These mergers usually achieve market integration. Harmonization of derivatives exchanges create regional or global leaders. Transatlantic mergers and multinational dispersion follow this. Mergers that lead to diversification in the scope of asset classes, data and IT services as well as the value chain are also common in the multiway integrated CMIs. On the other side, emerging markets consolidate vertically in the value chain and differentiate asset classes served within their national borders. Lees (2014) provides a short classification of mergers and consolation of major exchanges in six variants. These are within nation consolidation, cross border regional consolidation, acquisition of alternative trading systems, pan-European and Transatlantic mergers and other alliances. On the other side, we provide a more comprehensive global classification for all types of CMIs. Our classification depicts the merger waves with respect to the integration and diversification patterns in horizontal, vertical and multiway levels (Figures 3.4).

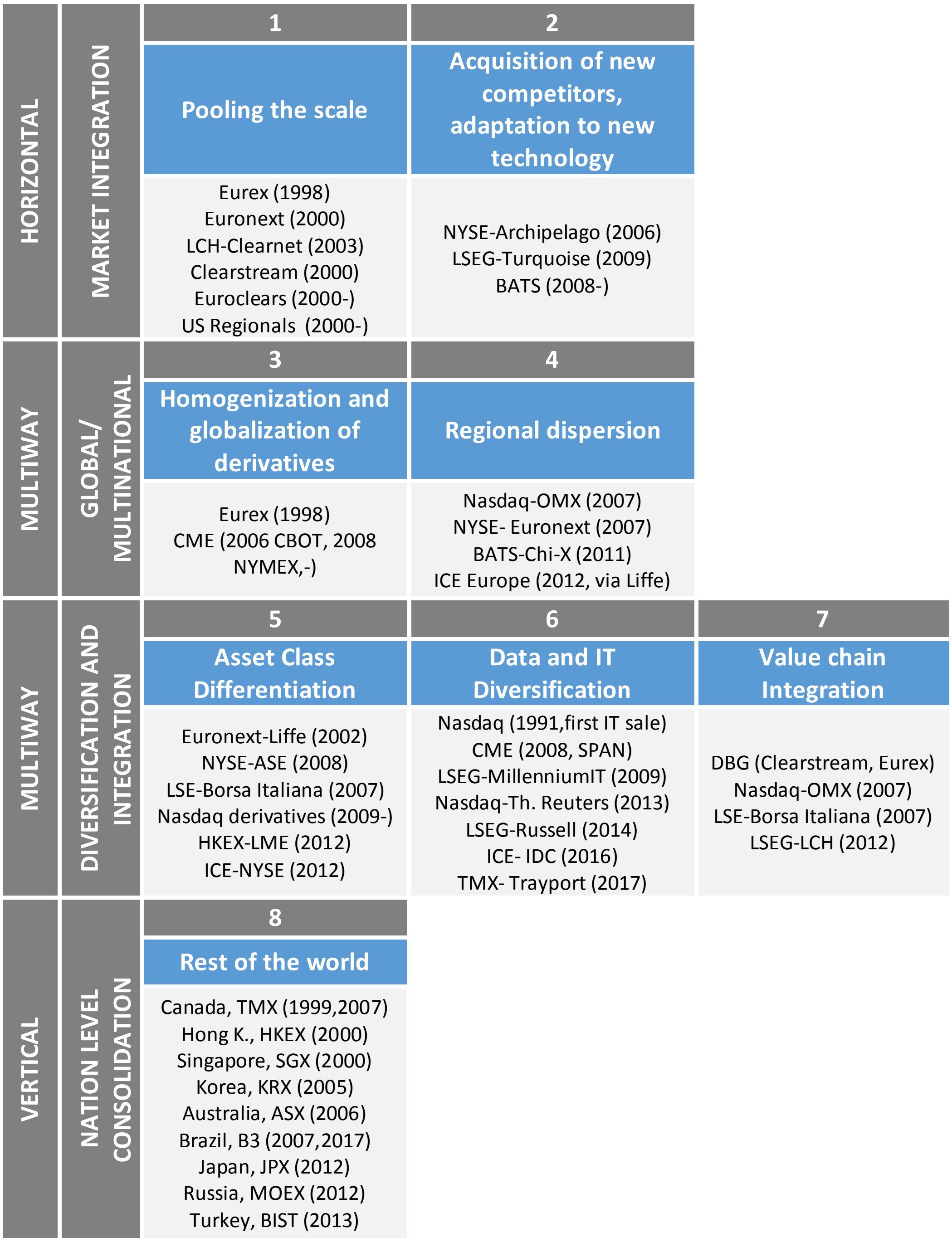


Figure 3.4 : Classification of merger waves.

Following the introduction of EUR as single currency in 1999, horizontal mergers of exchanges, clearing houses and CSDs dominated European area in early 2000s. Euronext is established with merger of Paris, Amsterdam and Brussels exchanges. Eurobond depository and settlement bank Euroclear acquired initially CSDs of France, Belgium and Netherlands, other CSD acquisitions followed. Similarly, CEDEL merged with German CSD under DBG. They created today's ICSD model. On the clearing side, London based clearing house LCH acquired French clearing house

Clearnet. All these mergers are horizontal and pool trade execution, clearing, or settlement activities in one infrastructure.

In the US on the other side, regional exchanges merged among themselves or with the bigger exchanges. These mergers create a market driven integration in the US and Europe. Meanwhile, alternative trade execution venues challenged trade execution of the exchanges by their innovative technologies. Therefore, second wave came in the form of acquisition of alternative trading venues by big exchanges in the US and Europe. Acquisition of the Archipelago ATS by the NYSE in 2006 and Turquoise by LSE in 2009 are major examples. BATS was founded in 2005 as an ATS. It acquired several other ATS and grew to be a regulated exchange in 2008. BATS is an example of an ATS growing up to one of the largest exchanges.

On the derivatives side, fragmented exchanges are consolidated under-regional or global level exchanges. The consolidation in derivatives created globally traded homogenous derivatives asset types. Establishment of Eurex in 1998 as joint venture between Deutsche Börse and SIX Swiss Exchange is an early example of merger events history. This merger created the largest derivatives exchange in Europe. In the US, merger of ICE with CBOT in 2006 created world’s largest derivatives exchange. CME Group grows with further mergers with other derivatives and commodities exchanges in the US, it has a global client base. Regional dispersion continued with transatlantic mergers. NYSE merged with Euronext in 2006, however demerged after the acquisition of NYSE by ICE (2013). Nasdaq is the longest living transatlantic multi asset class exchange. BATS acquired Chi-X Europe in 2011 to have a presence in Europe. ICE group have operations in Europe with ICE Europe (former Liffe) and Holland Clearing House.

CMIs integrate and diversify further in multi dimensions. They aim to diversify further in other revenue generating business lines and integrate the value chain. These include increasing the asset type scope, providing data and IT services or integration of clearing and settlement with exchange business. Acquisition of Liffe by Euronext (2002) is an early example of diversification by means of asset class differentiation. After merger of Euronext with NYSE (2006) and acquisition of NYSE by ICE (2012), Euronext disintegrated from ICE Group (2013), Liffe stayed with ICE. NYSE merged with American Stock Exchange (ASE) in order to diversify in equity options, LSEG diversified into pan European bonds market through MTS of Borsa Italiana. Nasdaq has been growing in US derivatives by several acquisitions since 2009. HKEX of Hong Kong acquired LME. It achieved asset type differentiation and diversified into commodity derivatives with the acquisition.

Coming to other business lines, Nasdaq is the first CMI that began technology sale. Today various exchanges worldwide use Nasdaq technology. For example, ASX cash trading platform runs on Nasdaq technology. BIST of Turkey has recently completed technology transformation for all trading and clearing infrastructure from Nasdaq. Tadawul of Saudi Arabia and NSE of India are in the process of technology transformation with Nasdaq. CME's risk management technology SPAN is also a worldwide used CCP risk management tool since 2008. LSEG merged with MillenniumIT in 2009 to catch up. SIX Group also have a lot of revenue from IT services, especially related to their payment services.

In recent years, exchanges intervene to data and information services business in order to realize the revenue in this line as well. Recent acquisitions have a strong trend. Nasdaq acquired Thomson Reuters' investor relations, public relations and multimedia businesses. LSEG acquired major index provider Russels in 2014, ICE acquired market data provider company IDC in 2015 and TMX acquired market analytics company Trayport in 2017. Data and information services contribute to the revenues of LSEG, ICE, SIX and TMX considerably (Figure 3.2).

Exchanges can also merge with clearing houses and CSDs to benefit from potential scale and scope economies. DBG established as vertically integrated German silo in 1992, evolved into multiway integration by further mergers in trade execution, clearing and settlement business lines across Europe. LSEG diversified to clearing and settlement first with Borsa Italiana in 2007, then by acquisition of majority shares of the LCH in 2012. Merger of NASDAQ with OMX in 2007 includes some clearing and settlement diversification as well.

Emerging markets also accepted the challenge of mergers and consolidation. These markets are usually consolidated within their national borders. They use national consolidation as a mechanism against acquisition of individual CMIs by global leaders. Canada and Asia Pacific countries are early responders, while, Turkey, Russia and Brazil completed nation level consolidations recently.

In Japan, for example, Tokyo and Osaka exchanges merged to form JPX successfully in 2013. ASX is established in 1986 as a consolidation of six independent exchanges in Australia. It acquired futures exchange and bonds post trade CMI in 2006 and established nation level CMI silo. In Brazil, Canada, South Africa, Turkey, Russia, Saudi Arabia, Singapore, Hong Kong and Switzerland national level mergers of securities exchanges with derivatives exchanges as well as post trade CMIs created effective nation level consolidation. Among these TMX of Canada, HKEX of Hong Kong and SIX of Switzerland have some cross-border acquisition that reveals their determination to grow with multiway integration. However, they still have national focus and have not yet proven themselves as global multinational CMIs.

Strategic alliances among the emerging markets are also tried in response to the mergers and consolidations in the developed markets, however, they remain mostly unsuccessful. The main reason is the national protective focus of the allied CMIs and their national regulators. For example, In Asia Pacific ASEAN link incorporated by the stock exchanges from Singapore, Indonesia, Malaysia, Vietnam, Philippines and Thailand in order to compete with other regional bigs. Similarly, MILA integrated exchange established by Colombia, Chile, Peru and Mexico in South America against Brazil. Nevertheless, these initiatives have some volume but could not consolidate trading activities in their target regions. Strong national fragmentation is dominant. The only successful merger is the CEE (Stock Exchange Group Holdings) established in 2010 by the merger of Vienna and Prague exchanges. Today it consolidates exchanges in East Europe (Vienna, Prague, Budapest and Ljubljana) on a single trading platform and post trade set-up successfully.

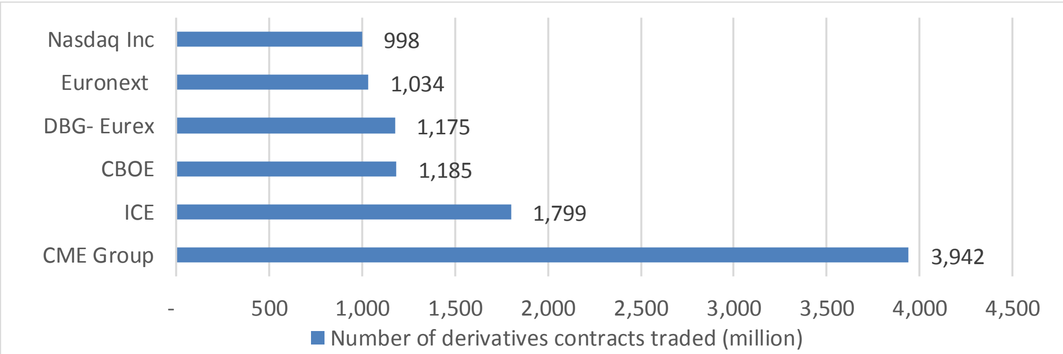
3.9 Mergers' Performance

Mergers' performance can be evaluated by the level of market integration and cost reduction it provides, improvements in market microstructure and increase in shareholders' value.

Mergers and acquisitions are successful to achieve market integration, reduced costs and technological innovation due to the consolidation of the activities. For example, Euronext achieved to consolidate Paris, Amsterdam and Brussels trades in a single order book. Today Euronext processes 54% of Eurozone trades (WFE, 2017). Euroclear Group, on the post trade side, safekeeps 48% and DBG's subsidiary

Clearstream 28% of securities in EU (ECSDA, 2016). DBG processes 33% of Eurozone securities trades and more than 80% of Eurozone derivatives contracts traded (WFE, 2017). DBG's subsidiary Eurex and LSEG's subsidiary LCH are the two major clearing house/CCPs in the EU. Today CME Group integrates seven derivatives exchanges in one trading and clearing technology. It is the largest derivatives exchange in the world and a quarter of the trading activities initiated outside US. Figure 3.5 presents the number of derivatives contracts traded on selected global exchanges.

Gains to the shareholders are also evident. Geranio (2016) documents the price performance of the exchanges after merger events. In the US, Europe and Asia Pacific, all mergers outperformed the market and provide their shareholders superior to the average market performance. Otchere, Antwi and Mohsni (2013) shows that exchanges' IPOs are underpriced more compared to regular IPOs. They also showed that exchanges' market performance outperforms the market index significantly.



Data is obtained from WFE Statistics and BIS CPMI Redbook (2016)

Figure 3.5 : Number of derivatives contracts traded in selected exchanges (2016).

There is plenty of literature on the effects of Euronext merger on market microstructure as well as cost reductions. Pagano and Padilla (2005) show that merger of Amsterdam, Brussels and Paris exchanges benefited the market in terms of reduced cost and increased market microstructure aspects. Their study reveals that IT and overall costs reduced by 29 % and 24 % post-merger. Average trading fees were reduced by 30 % for Paris and Brussels, 45 % for Amsterdam. Direct access and no intermediation costs are also for the benefit of market participants. In addition, bid ask spreads were reduced between 38% and 48 % for Paris stocks, between 23% and 30 % for Brussels stocks and between 4% and 11.5 % for Amsterdam stocks. Total trading volume increased by 40 % and volatility of large capital stocks decreased by 9 % to 18%. Slimane (2012) shows that Euronext consolidation has no significant effect on the volatility of the integrated markets. Positive effects of consolidation are on cost savings and increased liquidity. Based on data from Nasdaq Nordic exchanges, Hellström, Liu and Sjögren (2013), found that long run market return correlation increases and short run deviations from the long run return trend persists shorter after merger of exchanges. Choi (2009) examined post-merger performance of the Asia Pacific exchanges after merger events, SGX, HKEX and KRX. The results reveal that number of listed firms, value of trading, turnover rate and market capitalization have increased significantly in years after the merger. Teplova and Rodina (2016) investigated liquidity in Russian stock market after the establishment of MOEX in 2011. They investigated one-year period after the merger and found that overall liquidity has fallen in the market. However, blue-chip segment remained unaffected. A flight to offshore trading venues is seen as major threat for MOEX. Ülengin and Yobaş (2013) show that trading volume in the markets after the merger events depends on the macroeconomic indicators. They show that trading volumes increase after the merger if macroeconomic indicators are positive. Their results indicate that merger performance is positive under favorable macroeconomic conditions.

Today most of the CMIs are integrated through mergers. It is hard to find any exchange or post trade CMI that still remains independent. Economies of scale is evident in the industry, empirical findings are supportive (Schmiedel, Malkamäki and Tarrka, 2006; and Cayseele and Wuyts, 2007; Sharper, 2012). However, merger patterns in terms of business integration and diversification models still remain widely untouched in terms of economic analysis. Horizontal, vertical, multiway integration and diversification aspects of the merger and acquisitions are widely discussed in the remainder of the dissertation. Specifically, Chapter 4 discusses the economies of CMIs in terms of cost and economic efficiency with focus to integration models. Chapter 5 presents an empirical study.

3.10 Detailed Presentation of CMIs

This section presents detailed description of the CMIs presented in Figure 3.1. These descriptions provide rich background in the formation and evolution of each CMI individually and in relation with others.

3.10.1 Brazil Bolsa Balcao (B3)

Bovespa (Bolsa de Valores de São Paulo) is established as state owned institution in 1890. It is transferred to the private sector as a member-owned entity in 1965. The company went public and was listed in its own exchange in 2007. In 2008, BM&FBOVESPA is established by merger with the Brazilian Mercantile & Futures Exchange (BM&F). BM&FBOVESPA and Cetip merged in March 2017 and the group is renamed as Bolsa Balcao (B3).

B3's scope of activities includes the creation and management of trading systems, clearing, settlement, deposit and registration for the main classes of securities. These include equities, corporate fixed income securities, currency derivatives, structured transactions, interest rate, and agricultural commodities. It also has OTC trading, clearing and settlement facilities. B3 also acts as a central counterparty for most of the trades carried out in its markets and offers central depository and registration services. Brazil is a beneficial owner market and B3 is the sole capital market infrastructure provider.

Bovespa division provides trading platform for equities and equity options while BM&F division for spot and future commodities. Cetip has electronic OTC trading facilities. There have been four clearing houses in the country before the merger. With the merger B3 consolidated CCPs and CSDs in Brazilian market.

3.10.2 ICE (Intercontinental Exchange Inc.), USA

ICE (Intercontinental Exchange, Inc.) is US based leading global operator of regulated exchanges, clearing houses and listings venues. It is listed on New York Stock Exchange.

The Group has four equities and bonds listing and trading exchanges and one equities trading exchange under NYSE (New York Stock Exchange). Group also has eight derivatives exchanges, two OTC derivatives trading platforms, two ATS for bonds and six clearing houses. One exchange (Natural Gas Exchange- NGX) has both trading and clearing functions. Energy, agricultural and financial futures contracts as well as equity options are the main instruments traded and cleared in-group's exchanges. Credit default swaps and OTC energy contracts are the main OTC derivatives instruments traded and cleared. Fixed income instruments are traded on group's ATS.

All derivatives are traded on one platform while equities on three distinct platforms. Group has one clearing technology.

ICE Futures US and ICE Futures Europe (former LIFFE) are exchanges for futures and options contracts based on energy and agricultural commodities, interest rates, equity derivatives and emissions in US and European regions. ICE Clear US and ICE Clear Europe Clear contracts are traded on these exchanges. ICE Futures Canada is the Canadian agricultural futures and options exchange. ICE Clear Canada clears contracts traded on ICE Futures Canada. ICE Futures Singapore (former Singapore Mercantile Exchange- SMX) lists futures contracts for energy, gold and foreign exchange commodities. ICE Clear Singapore provides clearing for ICE Futures Singapore. NYSE American Options, formerly known as NYSE Amex Options and NYSE Arca Options, are US equity options exchanges based in New York and San Francisco. They both offer order execution through hybrid model, with both electronic trading and open outcry. ICE Endex is a leading continental European energy exchange providing regulated markets for natural gas and power derivatives, gas balancing markets and gas storage services and is based in Amsterdam, the Netherlands. ICE Clear Europe provides clearing for ICE Endex. NGX, is a Canadian exchange which provides electronic execution, clearing and data services to the North American natural gas, electricity and oil markets. The group also has a clearing house in Netherlands that clears Dutch equity options (Holland Clearing House).

Group's OTC markets include both regulated and unregulated platforms for the execution of cleared and bilateral, or non-cleared, CDS instruments and energy contracts. Creditex US and UK and ICE Swap Trade provide execution services to the global credit default swap market and financially settled bilateral energy markets. ICE US OTC Commodity Markets provide electronic trading of contracts based on physically settled natural gas, power and refined oil contracts. ICE Clear Europe and ICE Clear Credit clears OTC trades. ICE Credit Trade and BondPoint are the two alternative trading systems (ATS) that provides dealer to dealer and dealer to client electronic execution services for government, municipal and corporate fixed income instruments.

ICE has three listing equities exchanges, one bond listing and trading venue and one trading venue under NYSE Group Inc. The New York Stock Exchange is a leading global cash equity exchange. In addition to common stocks, preferred stocks and warrants, the NYSE lists structured products, such as capital securities and mandatory convertible securities. In addition, NYSE operates NYSE Bonds, an electronic trading platform with transparent pricing for debt securities, including corporate bonds. NYSE American supports emerging growth companies by providing a listing venue for a broad range of companies that may not qualify for listing on the New York Stock Exchange. NYSE Arca is the leading listing and trading platform for ETFs and exchange traded notes. NYSE Arca also lists and trades securities options. Recently acquired NYSE National is a trading venue, not a listings market. NYSE Group acquired American Exchange (renamed NYSE American) in 2008 and National Exchange (NYSE National) in January 2017.

3.10.3 Nasdaq Inc., USA

Nasdaq is a global infrastructure originated from the US. In 2008 it merged with OMX Group and extended its global coverage to Europe. In equities Nasdaq provides primary market listing services in eight markets (one US, four Nordic, three Baltic), and secondary market trading services in thirteen markets (six US, four Nordic, three Baltic). For fixed income Nasdaq has two trading platforms (US trading platform and Nordic). For derivatives Nasdaq has eight exchanges (seven US, two European- Oslo ASA and Nordic). In total Nasdaq has 24 markets. The group also owns a European CCP (Nasdaq Clearing) and two CSDs (Baltic and Iceland) in Europe. Nasdaq, Inc., stocks are listed on its own securities exchange since 2002, under the ticker symbol NDAQ.

In the US, group operates three cash equity exchanges. The Nasdaq Stock Market is a listing and trading market. Nasdaq BX and Nasdaq PSX are trading markets. In 2015 Nasdaq acquired Canadian alternative trading platform Chi-X Canada. With this acquisition, group also operates three markets for the trading of Canadian-listed securities. In Europe, Nasdaq operates listing and trading services through its exchanges under Nasdaq Nordic in Stockholm (Sweden), Copenhagen (Denmark), Helsinki (Finland), and Reykjavik (Iceland). Group also operates exchanges under Nasdaq Baltic in Tallinn (Estonia), Riga (Latvia) and Vilnius (Lithuania). Nasdaq owns two central securities depositories that provide services in the Baltic countries and Iceland.

Nasdaq Inc. operates six electronic options exchanges in the US; namely Nasdaq PHLX, The Nasdaq Options Market, Nasdaq BX Options, Nasdaq ISE, Nasdaq GEMX and Nasdaq MRX. These exchanges facilitate the trading of equity options, ETF options, index options and foreign currency options. NFX is a US based designated contract market, which lists cash-settled energy derivatives based on key energy benchmarks including oil, natural gas and US power.

In Europe, Nasdaq offers trading in derivatives, such as stock options and futures, index options and futures and fixed-income options and futures in Nordic Markets. Nasdaq Oslo ASA is the commodity derivatives exchange for European products and freight. All trades with Nasdaq Oslo ASA and Nordic Market and Nasdaq Commodities are subject to clearing with Nasdaq Clearing.

Nasdaq Fixed Income platforms provides trading for fixed income instruments. The US portion of Nasdaq Fixed Income includes an electronic platform for trading US Treasuries. The European portion of Nasdaq Fixed Income services are provided through Nordic Markets.

Nasdaq Clearing offers clearing services for equities, fixed-income options and futures, stock options and futures, index options and futures, and interest rate swaps by serving as the CCP in Europe. Nasdaq Clearing also operates a clearing service for the resale and repurchase agreement market. It is a CCP authorized under EMIR. Securities are settled through the relevant CSDs. In the US region, all trades in derivatives exchanges are cleared by OCC. All securities trades are cleared and settled through DTCC.

3.10.4 CME Group, USA

CME Group Inc. is the largest derivatives exchange at global level. CME was founded in 1898 as a not-for-profit corporation. In 2000 CME demutualized and in 2002 went public in New York Stock Exchange. Then after, a set of mergers and acquisitions followed. In 2007 the company acquired CBOT exchange and the group is renamed CME Group. In 2008 the group acquired NYMEX and COMEX, in 2012 KCBT. Today it is listed in Nasdaq Stock Market under the symbol CME.

The Group provides infrastructure for seven markets in eight instrument categories through a single technological trading and clearing platform (Globex). 95 % of trades is accomplished electronically through Globex platform. The group also performs

OTC, block transaction and swap clearing through its platform ClearPort. Instrument categories are agriculture, energy, equity ETFs, FX, interest rates, metals, real estate and weather. In 2017 the Group quit its trading and clearing activities in its European trading and clearing subsidiaries (CME Europe Limited and CME Clearing Europe Limited) and consolidate European operations with US.

The exchange divisions are CME (Chicago Mercantile Exchange), CBOT (Board of Trade City of Chicago), NYMEX (New York Mercantile Exchange), COMEX (New York Commodity Exchange), GEM (Growth and Emerging Markets), IMM (International Monetary Market), IOM (Index and Option Market). The group activities include centralized clearing. In CME business model, clearing services are bundled with trading. The group has subsidiaries in several jurisdictions worldwide. Operations are technologically and business wise consolidated.

3.10.5 CBOE Global Markets, USA

Chicago Board Options Exchange (CBOE) was founded in 1973 and is the first organized market for listed equities options. It extended its business to futures exchange in 2004. In 2010 it went public and began listed in Nasdaq Stock Market. In 2017 CBOE Holdings merged with BATS Global Markets and formed CBOE Global Markets. As a result of the merger, the group extended its services to equities and FX as well as options and futures. As part of the acquisition of Bats Global Markets, Cboe Global Markets began migrating trading in all of the company's markets onto a single platform powered by Bats' proprietary trading technology.

Options are traded on CBOE markets, namely Cboe Options, C2, BZX and EDGX. Options business include market index options, single stock options and other exchange traded products (ETPs) such as ETFs and exchange traded notes (ETN). CFE is the futures exchange which lists futures on the VIX Index and bitcoin and other futures products. The US Equities markets are BZX, BYX, EDGX and EDGA on which listed cash equities and ETP transaction services occur. In Europe, pan‑European listed cash equities, ETPs, exchange‑traded commodities, and international depository receipts transactions take place on Cboe Europe Equities and Cboe Chi-X Europe. The Global FX segment includes institutional FX services and non-deliverable forward FX transactions.

3.10.6 Depository Trust and Clearing Corporation (DTCC), USA

DTCC is the clearing and settlement institution in US securities. DTCC embraces all post trade services for securities.

Depository Trust Company (DTC) provides central securities depository, settlement and related services. Primary market services include issuance and related services provided to the issuers (such as proxy voting, position reports etc.). It also provides asset services such as corporate actions, tax and optional registry (direct registration system) services.

DTCC provides clearing services for equities, government fixed income, mortgage backed securities, corporate, municipal bonds and unit investment trusts. National Securities Clearing Corporation (NSCC) provides clearing, settlement, risk management, and CCP services to its members for broker-to broker trades involving equities, corporate and municipal debt, exchange-traded funds, and unit investment trusts. NSCC also has fund services (fund/serv). Fixed Income Clearing Corporation (FICC) is a clearing agency registered with the SEC that provides CCP services to members that participate in the US government and mortgage-backed securities markets, consisting principally of automated real-time trade comparison, netting, clearance, settlement, trade confirmation, risk management and electronic pool notification. FICC has two divisions: The Government Securities Division (GSD) and the Mortgage-Backed Securities Division (MBSD).

DTCC ITP LLC, formerly known as Omgeo LLC, provides post-trade matching, processing and other related services, primarily to members of the financial community. Deriv/SERV, through its subsidiaries and affiliates, enhances transparency and provides operational efficiency for the derivatives market. It is the trade repository system supporting a multitude of data submissions, including real-time price reporting. DTCC also operates Direct Registry System (DRS) that provide beneficiary services to transfer agents and issuer companies.

3.10.7 Options Clearing Corporation (OCC), USA

OCC delivers risk management, clearing and settlement services for options, futures, OTC derivatives and securities lending transactions. Exchanges, alternative trading systems and OTC trade sources for options, futures and OTC products have links to OCC to process the clearing facilities.

BOX Options Exchange LLC, Cboe Exchange, Inc., Cboe BZX Options Exchange, Cboe C2 Exchange, Inc., Cboe EDGX Options Exchange, MIAX Options Exchange, MIAX PEARL, LLC, Nasdaq BX Options, Nasdaq GEMX, Nasdaq ISE, Nasdaq MRX, Nasdaq Options Market, Nasdaq PHLX LLC, NYSE American Options, NYSE Arca Options are the options exchanges served. Cboe Futures Exchange, LLC, Nasdaq Futures, Inc. and OneChicago, LLC are the futures markets served. Automated Equity Finance Markets, Inc. (AQS) is the alternative trading system for securities lending served. MarkitSERV is the OTC trade source served.

OCC is assumed to be working in a competitive environment. Although there is no other central options clearing house, options and futures exchanges may choose to clear their own trades.

3.10.8 TMX Group, Canada

Toronto Stock Exchange (TSX) is formally established in 1861. TSX is the equities exchange and incorporates Venture and Alpha exchanges. It merged with Montreal Exchange (MX) and formed TMX Group in 2008. The group includes several equities, fixed income, derivatives and energy exchanges, CCPs and CSDs as well as information and analytic services. It is listed in TSE; vast majority of the shares are controlled by Canadian banks and financial institutions.

TSX and TSX Venture provide primary market services. Alpha operates as a trading venue. Group's trading platform Shorcan acts as an inter-dealer bond broker (IDB) that specializes in the Canadian fixed income marketplace. Montreal Exchange (MX) provides interest rate, index, equity and exchange-rate derivatives to Canadian and international market participants. TMX Group subsidiary BOX is an all-electronic equity derivatives market and is one of a number of equity options markets in the US. All BOX trade volume is cleared through the OCC. TMX Group provides mutual funds trading platform TSX NAVex. The Group sold its energy derivatives exchange NGX to ICE in 2017.

The Canadian Depository for Securities Limited (CDS) is Canada's national securities depository, clearing and settlement hub for domestic and cross-border depository-eligible securities. CDS is acquired by the TMX Group in 2012. Canadian Derivatives Clearing Corporation (CDCC) is a subsidiary of MX. CDCC provides CCP clearing and settlement services for all MX transactions and certain over-the-counter (OTC) derivatives, including fixed income repurchase and reverse repurchase agreement (REPO) transactions. TMX has begun aligning CDS and CDCC under an integrated post-trade services strategy.

The group's revenues are composed of securities trade and post trade services (55 %), derivatives trade and post trade services (17 %) and information services (28 %).

There are several Alternative Trading Systems (ATS) operating in Canada. These include Liquidnet for debt, MATCH Now, Pure Trading, Nasdaq Canada and Omega ATS for equities. The OTC trading is in some equities and in all types of debt securities.

3.10.9 London Stock Exchange Group, (LSEG), UK

London Stock Exchange is the world's first regulated exchange, formally established in 1801. Its history traces back to 1698. In 1973 it consolidates 12 regional exchanges and reestablished in its modern form in 1986 with Big Bang Regulation. In 2001 it is listed in its own platform with symbol LSE. In 2007 it merged with Milan Stock Exchange (today Borsa Italiana) and formed London Stock Exchange Group (LSEG). In 2009 it acquired Turquoise derivatives division and formed London Derivatives Market. In 2013 the Group acquired LCH.

Today LSEG have operations in securities and derivatives trading, clearing and settlement. Listing and trading infrastructures are provided through London Stock Exchange and Borsa Italiana. Turquoise is the group's pan European multilateral trading platform for equities, MTS for fixed income instruments. The group provides clearing and settlement services in Italian market through the Italian CCP (CC&G) and CSD (Monte Titoli). The groups' main post trade infrastructure is the LCH Group which operates under two entities in France and UK. LCH is a pan European clearing house and CCP, it has a global client base. LCH clears equities and exchange traded derivatives as well as European sovereign bond and repo transactions (RepoClear). It also has OTC clearing platforms for interest rate swap contracts (SwapClear), credit default swap contracts (CDSClear) and non-deliverable contracts in foreign exchange markets (ForexClear). LCH history dates back to 1888. It is merged with the French Clearing House Clearnet in 2003. LSEG acquired the majority stocks of LCH in 2012.

LSEG also have a European trade repository. Together with trade and post trade services information services composes one third of yearly revenue of the group. In

2017, 38 % of the total revenues of LSEG stems from information services, 37 % from post trade services are clearing, and %20 from listing and trade matching services.

3.10.10 Euronext, Europe

Euronext was formed in 2000 with the merger of the Paris, Amsterdam and Brussels exchanges. It acquired the London-based derivatives market, the London International Financial Futures and Options Exchange (LIFFE) in 2001, and merged with the Portuguese exchange, BVLP, in 2002. It became listed in 2001. It merged with NYSE Group in 2007, then it was acquired by the Intercontinental Exchange (ICE) in 2013 when the NYSE Euronext Group was purchased by ICE. In June 2014 Euronext detached itself from ICE through an IPO. The Euronext initial public offering, held on June 19, 2014, and the stock trades in Paris, Amsterdam and Brussels under the “ENX” symbol.

Today Euronext operates six exchanges in Europe. It provides securities listing for exchange lists equities, bonds, funds and ETFs as well as trading for securities and derivatives trading infrastructure. It operates four national regulated securities and derivatives markets in Amsterdam, Brussels, Lisbon and Paris, a regulated securities market in Ireland (Euronext Dublin) and the UK-based regulated securities market, Euronext London. All markets are operated by a single order book with a single access for securities and derivatives trades.

Euronext also operates a number of multilateral trading facilities, including its SME (small to medium enterprise) and midcap dedicated marketplace Euronext Growth (formerly Alternext) (Belgium, France, Portugal), Euronext Access (formerly the Marché Libre) in Belgium and in France, BondMatch for institutional bond trading (France) and Euronext Block a pan-European equity block pool (United Kingdom). Euronext acquired 90 percent of FastMatch, an electronic communication network for trading foreign exchange, in May of 2017 and 100 percent of Irish Stock Exchange in March 2018.

3.10.11 Euroclear Group, Europe

Euroclear Group is a pan European CSD. It has a banking license through its ICSD, Euroclear Bank. Euroclear operates CSDs of UK and Ireland, Belgium, France, the Netherlands, Sweden, and Finland as well as the ICSD. The instruments deposited includes equities, non-government bonds and money market instruments and Eurobonds. Euroclear services includes core CSD services settlement, custody and corporate actions. It also provides mutual fund trading platform, securities lending services, tri-party collateral management services and banking services.

Euroclear system is created in 1968 by the Brussels office of Morgan Guaranty Trust Company of New York in order to facilitate settlement of Eurobonds with delivery versus payment method. In 1972 the system is sold to Euroclear Clearance System Public Company. In 2000 the company is reshaped as a bank. In 2001 Euroclear acquired CSD of France, Netherlands and Belgium, in 2002 CSD of UK and Ireland, in 2008 CSDs of Sweden and Finland. In 2013 it opened Poland branch to extend our dual-office arrangement with operations teams in Belgium. The group also has branches in Hong Kong and Japan.

The Euroclear Group is a public company owned by 133 of the world’s major banks, broker dealers and financial institutions. The shareholders are active users of Euroclear services.

3.10.12 European Central Counterparty N.V. (EuroCCP)

EuroCCP is a pan European CCP founded in 2007. It covers 27 exchanges and alternative trading platforms from European Union and United States. It operates with direct securities account link to the 15 CSDs in its coverage. It has direct link to the central banks for cash side of settlements in EUR, DKK, NOK, SEK and CHF. It is a directly connected party (DCP) in Target2 for Securities.

ABN AMRO Clearing Bank, Nasdaq, DTCC, Cboe Europe and Euronext are the shareholders, all have 20% share.

3.10.13 Deutsche Börse Group (DBG), Germany

Deutsche Börse Group (DBG) is Germany originated European leading infrastructure. It is founded in 1992 in consolidation of German stock exchanges, derivatives exchange and CSD. Group provides primary market and secondary market trade infrastructures through Xetra. Xetra has a multilateral trading platform (Tradegate). Eurex is established in 1998 for derivatives transactions as joint venture between Deutsche Börse and SIX Swiss Exchange. The entity wholly acquired by DBG in January 2012. Today Eurex has electronic trading platforms for European derivatives

(Eurex Exchange), commodities (EEX group) and foreign exchange (360T). Eurex Repo Markets offers integrated markets for trading, clearing, collateral management and settlement for repo and securities lending transactions. Eurex also provides CCP services for the markets it operates as well as trades from Xetra platform. In addition, EurexOTC Clear is the clearing platform for interest rate swap contracts.

The group also owns the German CSD, Clearstream Frankfurt, and Luxembourg based ICSD, Clearstream Banking Luxembourg. Clearstream Luxembourg (ICSD) was founded in 1970 under name “CEDEL”, then in 2000 merged with German CSD under DBG. Clearstream provides issuance and settlement services for German as well as international securities, it also provides settlement and custody services for 57 markets worldwide. Clearstream is a bank, has differentiated products such as collateral management services and investment fund services.

3.10.14 SIX Group, Switzerland

SIX Group is formed in 2008 with merger of Swiss Exchange Group (securities trading), Telekurs Group (financial information and payment services) and SIS Group (post trade securities services).

SIX Swiss Exchange is the securities exchange in Switzerland in which equities, fixed income and other securities. Former derivatives exchange (Swiss Options and Financial Futures Exchange -SOFFEX) established in 1988 and incorporated under Eurex in 1998. OTC derivatives transactions are available among market participants.

SIX Securities Services group includes CSD (SIX SIS) and CCP (SIX X-Clear). SIX x- clear is recognized by ESMA and operates under competition with other clearing houses in EU. Interoperability exists with LCH. SIX Group acquired Oslo Clearing in 2014. SIX SIS is the CSD for Swiss equities and non-governmental debt instruments. It accomplishes settlement, depository and custody functions. SIX SIS has also linked to ICSDs as well as many other CSDs and provide global custody services on top of CSD functions for Swiss market. Fund services as well as collateral and repo services are also available for both local and global markets. It is also trade repository. SIX SIS is a bank, as well.

SIX Group’s 40 % of revenues stems from payment services, 26 % from exchange and securities services, 20% from information services and 8 % banking services (2018). SIX Group is an unlisted public limited company. Shareholders are mainly banks.

3.10.15 Target 2 for Securities (T2S), Europe

T2S is a pan European securities settlement platform operated by European Central Bank. It is initiated as a project in 2008 and went live between 2015 and 2017. Central Bank of Greece, Belgium, and CSDs of Malta, Romania, Switzerland, Italy, Portugal, Belgium, France, Netherlands, Denmark, Luxembourg, Hungary, Slovenia, Slovakia, Austria, Spain, Finland and Baltics (Estonia, Latvia and Lithuania) are fully migrated to the platform. The aim of the platform is to create a common settlement platform for Europe in order to reduce transaction costs and operational complexities in cross border settlements within Europe. The platform provides link with European Central Bank Payment Systems, thus, settlement in Central Bank money. Custodian Banks can also be direct participants of the system and provide fast transaction processing for their underlying clients.

Together with the regulations under Markets in Financial Instruments Directive (MiFID), the European Market Infrastructure Regulation (EMIR) and the Central Securities Depositories Regulation (CSDR), T2S aims to harmonize European post trade landscape, eliminate differences in national market practices and increase competitiveness of European securities market in global scene.

3.10.16 Johannesburg Stock Exchange (JSE), South Africa

JSE formation dates back to 1887, it became formal exchange in South Africa after 1947 financial markets regulation. In 2003, alternative exchange AltX for small and mid-sized listing is launched. JSE acquired the South African Futures Exchange (SAFEX) in 2001 and the Bond Exchange of South Africa (BESA) in 2009. It was demutualized and listed on its own exchange in 2005.

JSE offers five financial markets namely equities and bonds as well as financial, commodity and interest rate derivatives. Commodities market includes warehouse receipts which are settled physically and derivatives contracts which are settled in cash.

Wholly owned subsidiary JSE Clear all trades that takes place on JSE trading platforms. JSE Clear is recognized as third party CCP by ESMA.

Other exchanges and trading platforms are available in the country. Equity Express Securities Exchange (EESE), ZAR X, 4AX and A2X are the new generation exchanges that got license from regulators after 2014. These exchanges aim to differentiate themselves from JSE with lower transaction costs and easier reach for both investors and issuers. However, these exchanges do not have any competitive volumes yet.

3.10.17 Strate, South Africa

Strate is an independent company that serve to multiple stock exchanges in South Africa. JSE owns 44.55 % of Strate shares. Equities, bonds and money market instruments are deposited in Strate. Settlement and custody and corporate actions services are provided. It also provides tri party collateral management services.

Both beneficial owner and nominee concepts are recognized in the South African Securities market. Strate authorizes specific organizations (CSD participants) to provide custody services to investors. The beneficiary services of Strate includes register containing details of shareholders. The beneficiary information is supplied by CSD participants, brokers and Strate registered nominees.

3.10.18 Borsa Istanbul Group (BIST), Turkey

Istanbul Stock Exchange formation dates back to 1895, it is formally incorporated in 1986, its fixed income market is established in 1991. In 2012, with the new Capital Markets Law, it acquired Turkish Derivatives Exchange and Istanbul Gold Exchange. In the same year it consolidated the post trading services and rebranded as Borsa Istanbul Group. The exchange has four trading platforms for equities, fixed income, derivatives and precious metals.

Takasbank established as a department under Istanbul Stock Exchange in 1989 in order to provide clearing, settlement and depository services. In 1992 it is separated from the exchange and reorganized as incorporation. In 1996 it is organized as a special purpose bank. Depository services is separated from Takasbank in 2005 as the Central Registry System became operational under MKK, CSD of Turkey. In 2012, Borsa Istanbul increased its shares in Takasbank and MKK and consolidated the post-trade services. Money market, securities lending market and funds trading platform services are provided though Takasbank. Takasbank also operates central pension funds system of Turkey. MKK is also the trade repository.

In Turkey, Borsa Istanbul is the sole trading platform for equities. Interbank OTC fixed income market is available. Turkey is a beneficial owner market, where trading is accomplished in the name of the investor and securities are safekept and registered at the CSD in the name of the end investor/beneficial owner. In addition, in derivatives market margining is on investor basis.

3.10.19 Moscow Exchange Group (MOEX), Russia

MOEX is established by merger of Moscow Interbank Currency Exchange (MICEX) and RTS in 2011. National Settlement Depository (NSD) and National Clearing Center (NCC) are established in 1997 and 2006 as internally grew CSD and CCP functions. In 2013 the group went public and listed in its own exchange. Until November 2017 NCC had a banking license, since then it is regarded as non-bank credit institution. As non-bank credit institution, it is subject to a strict regulation and supervision from the Bank of Russia. It also has an access to the Central Bank's refinancing instruments.

MOEX provides full scope trading, clearing and settlement services. Equities, fixed income instruments and money market instruments (like Repo) are traded in Equities and Bonds Trading Platform. FX instruments and commodities are traded on FX trading platform. Derivatives are traded on derivatives trading platform. Clearing and margining at each platform was completed separately by NCC. Since 2017, project for unification and synchronization of clearing and CCP services for all Moscow Exchange platforms is being worked on. In addition to exchange clearing, OTC derivatives clearing is also provided by NCC.

Russia is beneficial owner market in general, nominee accounts have been allowed for foreign CSDs and ICSDs since 2012. MOEX is vertical silo that provides trading, clearing, settlement as well as listing and depository/custody services. There is no alternative trading venue in Russian market, still OTC trading is allowed.

3.10.20 Tadawul, Saudi Arabia

Tadawul is formed in 2007 in accordance with Saudi regulation for formation of stock exchange. Stocks, sukuks and bonds, ETFs REIT and mutual funds are traded on the exchange. Clearing, settlement and depository services are provided. Securities Depository Center Company (Edaa) has recently incorporated. It is also in process of formation of a CCP.

3.10.21 BSE India

Formerly known as Bombay Stock Exchange Ltd, BSE was established 'The Native Share & Stock Brokers' Association' in 1875. In 2017 BSE become the 1st listed stock exchange of India. Its shares are listed in NSE (National Stock Exchange) of India.

BSE has separate trading platforms for equity, debt instruments, derivatives, currencies, commodities, and interest rate derivatives. BSE has securities lending and mutual fund trading platforms, as well.

Indian Clearing Corporation Limited (ICCL), a wholly owned subsidiary of BSE, acts as the central counterparty to all trades executed on the BSE. Central Depository Services Limited (CSDL) was founded in 1999, as the securities depository of the group. In 2017 BSE reduced its shares in CSDL from 50.05% to 24% and CSDL is not a BSE subsidiary company since then.

India is a beneficial owner market. Two exchange groups BSE and NSE provide infrastructure for listing, trading and clearing. There are also two CSDs in the country; NSDL and CSDL. NSDL is founded as independent company but is promoted by NSE. CSDL was initially founded as subsidiary of BSE, however it also became independent company in 2017.

3.10.22 National Stock Exchange of India Ltd. (NSE India)

NSE India is founded in 1992. It provides trading for equities and linked instruments, derivatives and debt instruments. NSE provides securities lending and mutual fund trading. NSE has its own central counterparty clearing house (NSE Clearing) that accomplishes clearing of the trades take place on NSE platforms.

3.10.23 National Securities Depository Limited (NSDL), India

NSDL is the securities depository in India providing settlement and custody services. It is founded in 1996. Equities and related instruments as well as public and private debt instruments are deposited and safekept at NSDL. NSDL has launched NSDL Payment Bank Ltd, a wholly owned subsidiary with aim to make digital payments. The payment bank has the license from Reserve Bank of India and waiting for final regulatory clearance to begin operations.

IDBI bank Ltd. India and NSE are the main shareholders having 30 %, and 24 % of shares respectively. NSDL has links to the exchanges and/or their clearing houses to provide the settlement of trades that took place in these markets. It has link to NSE, Madras Stock Exchange Ltd. (MSE), Inter-connected Stock Exchange of India Ltd. (ISE), OTC Exchange of India (OTCEI), The Calcutta Stock Exchange Association Ltd (CSE), The Delhi Stock Exchange Association (DSE), The Stock Exchange Mumbai (BSE), The Stock Exchange Ahmedabad (ASE).

The two CSDs of India (NSDL and CSDL) serve to both of the two CCPs which are subsidiaries of the two competitive exchange groups BSE and NSE.

3.10.24 Singapore Exchange (SGX)

Singapore Exchange (SGX) is established in December 1999 by the merger of the Stock Exchange of Singapore (SES) and the Singapore International Monetary Exchange (SIMEX). SGX was itself publicly listed in 2000. SGX Securities Trading (SGX-ST), and Derivatives Trading (SGX-DT) divisions provides trading platforms for securities and derivatives. Debt instruments are traded on securities trading platform as well as equities and exchange traded derivatives and funds. Group perform trading activities under three legally separated wholly owned subsidiaries: Singapore Exchange Securities Trading Limited, Singapore Exchange Derivatives Trading Limited and SGX Bond Trading Pte. Ltd.

Singapore Exchange Derivatives Clearing Limited (SGX-DC) is wholly owned subsidiary of SGX. SGX-DC has qualifying CCP recognition form ESMA. It is CCP for derivatives traded at SGX-DT as well as OTC commodity trades registered via SGX trade registration platform and OTC financial derivatives trades registered via industry used trade registration system.

The Central Depository (Pte) Limited (CDP) is wholly owned subsidiary of SGX. It clears, settles and safekeeps securities, exchange-traded derivatives and funds as well as fixed income instruments. It provides CCP, securities settlement system and central securities depository services.

SGX has a leading international exchange in Asia Pacific with about 40% of listed companies and 75% of listed bonds originating outside of Singapore. It has links to selected securities in Nasdaq, ASX, Eurex, HKEX and JPX. GlobalQuote is the OTC market of the SGX which allows investors access to international securities listed on foreign exchanges.

Both omnibus and segregated account structure is accepted in the market. Singapore residents must hold segregated investor accounts at CSD level, while foreign investors/institutions are allowed to have omnibus accounts.

3.10.25 Hong Kong Stock Exchange (HKEX)

The Stock Exchange of Hong Kong (SEHK), Hong Kong Futures Exchange (HKFE) and Hong Kong Securities Clearing Company Limited (HKSCC), merged and established the Hong Kong Exchanges and Clearing (HKEX) in 2000. The HKEX listed in its own exchange since 2000.

HKEX has trading platforms for securities and derivatives. Equities, exchange traded instruments and trusts, warrants and debt securities are traded on trading platform. Equity index and single stock, FX, interest rate and commodity derivatives are traded in derivatives trading platform.

HKSCC is the clearing and settlement house as well as central depository for securities traded in HKEX. HKSCC is not legally central counterparty however it has margining and guarantee fund functions to guarantee settlement. Hong Kong Stock Exchange Options Clearing House Limited (SEOCH) clears stock options and Hong Kong Futures Exchange Clearing Corporation Limited (HKCC) clears all other derivatives. SEOCH and HKCC act as central counterparty and applies relevant risk and collateral management functions. The related trade records are updated real-time in the Derivatives Clearing and Settlement System (DCASS). DCASS is an integrated system covering both futures and options. OTC Clearing Hong Kong Limited (OTC Clear) is a central counterparty (CCP) established by HKEX for the purpose of providing clearing and settlement services for OTC derivative transactions. OTC Clear currently provides clearing of interest rate swaps (IRS), non-deliverable currency forwards (NDF), cross currency swaps (CCS) and deliverable FX (DFX).

3.10.26 Korea Exchange (KRX)

Korea Exchange (KRX) was formed on Jan. 27, 2005, from the merger of the Korea Stock Exchange (KSE), the Korea Futures Exchange (Kofex), the Kosdaq Market and the Kosdaq committee, part of the Korea Stock Dealers' Association. It provides an electronic platform for the trading, clearing and settlement of cash equities, bonds and derivatives. It is the sole platform for the listing and trading of stocks, bonds and derivatives in Korea. OTC trades among institutional investors is possible. KRX provides CCP clearing services for the trades that takes place in its own platform. The KRX's OTC CCP clears interest rate swaps.

Korea Securities Depository (KSD) is a subsidiary of KRX that provides settlement, depository and custody services. KSD provides CCP clearing services for OTC settlements that takes place among institutional investors and K-OTC. In addition to core central depository services such as settlement, depository and safekeeping, KSD provides securities lending, cross border settlement and global custody and fund trading platform (FundNet).

3.10.27 Japan Exchange Group (JPX)

JPX is formed by the merger of Tokyo Stock Exchange (TSE) and Osaka Exchange (OSE) in 2013 and listed in its own exchange (TSE).

Prior to the merger TSE and OSE were both differentiated exchanges that have both equities and derivatives sections. After merger equities trade transactions are consolidated under TSE and derivatives under OSE. Today JPX has one trading platform for equities and one for derivatives. Equities trading platform provide intra-structure for trading in stocks, funds, warrants, government bonds and other bonds. Derivatives markets products are options and futures with underlying assets as indices, bonds and individual equities.

Wholly owned subsidiary Japan Securities Clearing Corporation (JSCC) clears equities and bonds, futures and options listed on JPX as well as OTC Japanese government bonds, credit default swaps and interest rate swaps.

In Japanese market, multiple exchanges and alternative trading venues are available. Multi-Lateral Trading Facilities (MTFs) are named as Proprietary Trading System (PTS). Nagoya Stock Exchange, Sapporo Securities Exchange, Fukuoka Stock Exchange, Chi-X Japan PTS and Japannet PTS also provide exchange and/or trading venue services. Trades that takes place in these venues are cleared by JSCC.

3.10.28 Nagoya Stock Exchange (NSE), Japan

NSE is a securities exchange located in Nagoya, Japan. It formally founded in 1949, its history goes back to 1886. It is the second largest securities exchange in Japan after TSE. Stocks, investment trusts and bonds are listed on the exchange.

3.10.29 Tokyo Financial Exchange (TFX), Japan

TFX is established 1989. It provides trading and clearing for financial derivatives such as currency, interest rate and FX derivatives and equity derivatives. The exchange provides trading and clearing services in bundle. Investors have segregated trading/clearing accounts used for margining. TFX competes with Osaka Exchange (JPX Derivatives) in equities options and futures products.

3.10.30 Japan Securities Depository Center Inc. (JASDEC)

JASDEC is Japan’s securities depository. It provides book entry transfer systems for stocks and related, corporate bonds and investment trusts. It also has a DVP settlement system provided by wholly owned subsidiary Jasdec DVP Clearing Corporation (JDCC). It provides issuance/depository services to issuers and custody and corporate actions services to investors.

Both omnibus and segregated account structure is supported in the market. Shareholder must have segregate accounts in order to raise claims against issuers. Accounts are not segregated at CSD level. The account segregation of beneficial owners are applied at the custodian level, which are authorized depository participants.

3.10.31 Australia Stock Exchange (ASX)

ASX is established in 1986 as a consolidation of six independent exchanges in Australia. It is the first exchange that went public by listing in its own exchange (1998). It is merged with Sydney Futures Exchange and Austraclear in 2006.

Trading is provided in two trading platforms. ASX Trade is the cash market trading platform. Equities, exchange traded funds, exchange traded options, warrants, index options, interest rate securities, and Australian government bonds are traded on this platform. NTP provides access to the products listed on the ASX 24 market, including interest rate futures and options, equity futures and options, agricultural futures and options and energy futures and options.

ASX Clear is the central counterparty (CCP) for the trading of shares, warrants and exchange-traded funds traded on ASX Trade or via an Approved Market Operator (AMO). ASX Clear (Futures) is the central counterparty (CCP) for all futures and options products traded on ASX Trade24 and OTC products affirmed on an approved affirmation platform.

There is no formal CSD for equities. Equities are registered in the name of the custodian or agent or beneficial owner and held directly on the issuer's records. These holdings can be reflected on CHESS register which facilitates timely electronic and paperless settlement. ASX Settlement is Australia's settlement system and a fully electronic securities depository for equity and equity-related securities. Austraclear is Australia's settlement system and central securities depository (CSD) for the wholesale debt market.

There is competition in the Australian market, mainly form the alternative trading platform Chi-X Australia, which has around 20% market share. In addition, National Stock Exchange (NSX) founded in 1937, incorporated in 1972, then reactivated in 2000. It is a fully regulated exchange as market for small to medium, prominent regional businesses. It also operates the Bendigo Stock Exchange (BSX). Asia Pacific Stock Exchange (APX) is also a securities exchange in Australia. APX mainly offers Chinese market participants an alternative listing venue to the stock exchanges in China.

3.11 Final Remarks and Conclusion

Today, CMIs are private or public companies with merger and acquisition background. Figure 3.1 depicts the current global landscape and is arranged in the form of world map. The landscape is complicated in the US and Europe. Horizontal, vertical and multiway integrations as well as regional and asset class diversifications are available in developed markets. Emerging markets are associated with nation level vertical integrations. The world map provides a quick snapshot of integration and diversification aspects worldwide.

Merger history in the CMI industry began right after the completion of demutualization, in the beginning of 2000s. All integration aspects began in the US and Europe and dispersed to the rest of the world. The mergers have different patterns and motives. Pooling the scale, acquisition of the new potential rivals, globalization of the derivatives, regional dispersion, asset class diversification, integration back in the value chain and data and technology sale are major patterns.

Post-merger performance is evaluated in terms of market microstructure, shareholder valuation and cost reduction perspectives. Merged CMIs are shown to outperform the market average index in general. Market microstructure indicators such as volume and liquidity are also found to improve after mergers. Costs are also reduced due to scale economies following the mergers. However, analysis of merger patterns remains scarce. In this chapter we provide a detailed analysis of merger waves and analyze mergers in terms of integration and diversification motives they have in the background. This classification of the mergers fills the gap in the literature regarding the classification of mergers and acquisitions. Economies of horizontal, vertical and multiway integration as well as diversification aspects of the merger and acquisitions are presented in the following chapters. An empirical model for cost and pricing efficiency is also presented in the remainder of the dissertation.

4. ECONOMIES OF CAPITAL MARKET INFRASTRUCTURES

4.1 Introduction

Horizontal, vertical and multiway integrations, diversification to additional asset classes or related business lines and other linkage strategies are tools to increase network power as well as scale and scope economies. Details of these strategies are presented in chapter one. Adoption of these strategies by the CMIs and the evolution of global landscape are discussed in chapter two. In this chapter, we provide a comprehensive review on how these strategies and the landscape are modelled economically. We also provide economic literature on the empirical studies that tries to understand the correlation between these strategies and efficiency. More specifically, this chapter focuses on market design and network effects, efficiency measures, integration theory, economic impact of cost reduction and empirical findings on efficiency.

The characteristics of the industry are described with two sided network economies or public utility models. Global CMIs compete for liquidity provision, consequently, network power. Public utility model is adopted in case no competition is available. For example, DTCC in the US is the sole post trade CMI for securities. In most of the emerging markets, trade and post trade CMIs provide the sole infrastructure in their markets. Competition for network power in trade execution is an issue in developed markets. Post trade competition is specific to Europe in general.

Cost efficiency is achieving maximum productivity with minimum wasted expense. Economic efficiency or price allocation efficiency; it measures the level of competitiveness in the market. Production functions and profitability measures are used in order to measure cost efficiency and price allocation efficiency.

Theoretical models depict CMIs as profit maximizing firms and provide a game theoretic profit maximization approach. Empirical research focuses on the relation between total cost and output levels or profitability. Effects of horizontal and vertical integrations are tested within this set up. In most of the literature, the results are limited. They focus on either the exchanges or post trade CMIs. Most of the empirical work is based on the developed markets only.

In this chapter we will first discuss the microeconomic market design in the CMI industry. Then we continue to discuss efficiency measures, integration theory, costs and relation between integration and efficiency measures.

4.2 Market Design

The CMI industry is associated with high costs, entry barriers, strict regulation and natural monopoly position. Management of the counterparty risk, especially in derivatives markets, is also another unique feature of the industry. The characteristics of the industry are described with network economies (Milne, 2007; Polato ve Floreani, 2008; Cantillon and Yin, 2011) or public utility model (Knieps, 2006). Milne (2007) and Cantillon and Yin (2011) focus on the two-sided nature of the network economies in the industry.

Public utility model (Knieps 2006) argue that CMIs, especially CSDs, are regulatory infrastructures. They provide equal access to all financial intermediaries. They have only regulatory and notary function. Therefore, they are not monopoly bottle necks, they do not need to be competitive. Efficiency is not an issue. However, today most of the CMIs are private public companies. In developed markets, competition of CMIs, especially exchanges and other trade execution venues, is forefront. Global mergers and acquisitions bring about competition of various global networks.

Liquidity is the main network externality in trading. It is key to efficient price formation; still fragmentation of the trading venues exists. This phenomenon is regarded as network externality puzzle in market microstructure (Madhavan, 2000). In this argument, trade execution is assumed a homogenous product of the trading venues. Furthermore, switching costs are disregarded and demand for trading is exogenous. However, trading venues differentiate themselves in terms of market design to attract different portion of the heterogeneous traders. The microstructure offerings of the trading venues may affect demand for trading as well. High switching costs exist due to membership fees and technology adoptions that might be required. These costs are reduced in recent years due to open access policies and technological improvements in connectivity, though. Switching cost due to change in post-trade set up still remains.

Therefore, network externality is not a puzzle. Liquidity provision is an issue that CMIs compete for. Network power is directly related to pricing power.

Second characteristics of the industry is the two-sided nature. CMIs provide listing and issuance services to the issuers. These services are also named as primary market services. CMIs provide trade execution service to the traders, which is also known as secondary market services. These two sides of the market are interlinked. Issuers prefer the venues that are liquid and where their issues could easily be traded. Therefore, they also consider the trading liquidity and trading costs on top of cost of listing and issuance. Pricing and market structures in the secondary market side, affect preferences in the primary market. Foucault and Parlour (2004) models the link between issuer firms' gains from listing on exchange and the trading costs of a particular exchange. In their model, trading revenue of an exchange acts as a negative production cost for its listing business. Issuers discount costs in the secondary market together with the listing costs. Therefore, exchanges can strategically choose to apply lower trading fees and higher listing fees. Alternatively, they may apply other strategies depending on the strategy of the competitor exchanges. Kauko (2004) models CSD competition in the primary and secondary markets. Issuers can choose the CSD to issue securities. CSD-to-CSD link is available for the settlement of transactions in the secondary market. In this set up, CSDs compete in the primary market fees in order to keep their market share and liquidity provision in the secondary market. In this case, revenues from secondary market operations have higher share in the revenue structure of the CSDs. On the other side, Kauko (2007) changes the set up such that issuers cannot choose the CSD to issue securities. They are bound with regulatory issues and available practical set up to issue in their home country. In this case, CSDs reduce pricing for the secondary market services for local and cross border settlements. However, the reduced revenues from the settlement in the secondary market are compensated by higher primary market revenues. CSDs can use the account links as strategic commitment and increase fees applied to the issuers in the primary market.

In line with this literature trading and clearing revenues of derivatives exchanges are generally higher than securities exchanges. As also seen from Figure 3.2 derivatives exchanges have higher trading and clearing revenues than securities exchanges in general. Derivatives exchanges list the contracts to be traded themselves. Therefore, primary market does not exist. This means, no revenue alignment strategies are available between listing and trade execution in derivatives exchanges. In addition, derivatives exchanges provide more uniform trade execution service. Derivatives instruments are generally less restricted than securities in terms of the regulatory requirements. Therefore, global or pan regional derivatives exchanges can attract customers with more diverse geographical dispersion. CME Group and Eurex are major examples. Global or regional securities exchanges on the other side integrate multiple number of national exchanges. Nasdaq Inc. and LSEG are major examples.

4.3 CMI Efficiency Measures, Economies of Scale and Scope

Empirical studies on the CMI performance focus on the efficiency. Cost efficiency is achieving maximum productivity with minimum wasted expense. It measures efficiency of the production function of the firms, and also named as static efficiency in the literature. Translog total cost functions are generally used to see the effects of dependent variables on cost (Li and Marinč, 2016, 2018; Schmiedel et al., 2006; and Cayseele and Wuyts 2007). Data envelopment analysis (Serifsoy, 2007, Li and Marinč, 2018) and average cost per transaction processed (Serifsoy, 2007; Sharper, 2012, Li and Marinč, 2018) are also used to measure cost efficiency. Economic efficiency or price allocation efficiency measures the ability of the market conditions to have competitive pricing. Reduced profit margins and no excess profits are signs of competitive pricing. For the measurement of competitive pricing net profit ratio [net income/revenues] (Sharper, 2012), Lerner index [(price-marginal cost)/price] and correlation of profits with marginal costs (Boone Indicator) (Li and Marinč, 2016) are used.

Dynamic efficiency shows the openness to innovation in the long-run. It is not measured empirically, however, openness to efficiency is associated with openness to innovation in theory. Lastly systemic efficiency measures robustness of the market to deterioration of macroeconomic conditions, moral hazard and defaults of market participants.

Economies of scale shows increased cost efficiency due to increase in output levels. Economies of scope shows increased cost efficiency due to increase in product offerings. Horizontal, vertical and multiway integrations increase the output level, therefore they contribute to scale economies. With horizontal integration exchanges add new markets to their trade execution facility, CCPs and CSDs integrate their systems to multiple trading venues and market places. Vertical integration is integrating the trade execution activities with clearing and settlement. This is backwards integration in the value chain. Multiway integration is a combination of both. Product diversification is adding new asset types to the scope of services. A stock exchange providing a derivatives trading platform or acquiring another derivatives exchange, or a CCP providing securities clearing in addition to its derivatives clearing activities already in place are examples of product diversification. Horizontal integration can be interpreted as geographical diversification; vertical integration as value chain diversification. In most cases, multiway integrations enable CMIs not only to integrate horizontally and vertically, but also diversify in the asset classes served. Diversification in asset classes to which trading or clearing services are provided is also referred as product differentiation. CSDs provide facilities for securities only, therefore they cannot differentiate on the asset type due to the nature of their business. CSDs can diversify its functions to global custodian bank business line (Rochet and Toulouse, 2005; Holthausen and Tapking, 2007).

4.4 Integration Theory

Tapking and Yang (2006) shows in their two-country model that vertical integration is better than no integration. Vertical integration diminishes double margining effects in pricing as trade and post-trade infrastructures complement each other. Benefits of horizontal integration depend on the cost of technology transformation from the low cost CMI to the high cost CMI. If the cost of horizontal integration is not very high horizontal integration provides better welfare than vertical. Multiway integration, i.e. vertical integration in one market and horizontal integration with the other market, has the highest welfare effects as it provides a lot of scale efficiency, better technology adoption and elimination of double marginalization.

Pirrong (2008) also argues that vertical integration eliminates double marginalization effects, reduces cost of communication among trade execution, clearing and settlement platforms. Integration makes the linkages among the value chain functions less costly. Furthermore, clearing and settlement provides additional scale and scope economies to the exchanges. However, horizontal integration of clearing houses or CSDs among multiple trade execution venues may also provide scale economies. In this case, cost gains from scale economies in clearing or settlement can outperform the cost gains from vertical integration. In addition, clearing of multi asset classes by one clearer reduces margin requirements due to offset among the long and short positions in multiple asset classes. However, in this case, extended scope of the CCP would give it an excessive market power and monopoly position. Therefore, in most cases horizontally integrated post trade institutions are government initiated and strongly supervised. OCC and DTCC in the US, JASDEC in Japan are major examples. EU also takes this approach for settlement and initiated T2S project recently. These are public utility backed by the state or government. Pirrong (2008) argues that separation of post trade activity from exchanges and consolidation of these activities for multiple trade execution venues creates monopolies. It could be a source of opportunism and over marginal cost pricing. Thus, he argues that competitive vertically integrated exchanges is the best solution.

Juranek and Walz (2014) find out that increasing volume of alternative trade execution venues and algorithmic trading makes vertical integration less attractive for exchanges. Alternative trade execution increases total trading activity by pooling bilateral OTC trading and creating new ways of trading. Furthermore, it reduces trade executions in conventional regulated exchanges. In vertically integrated CMI model, exchange and post trade institutions use closed standards and technology; so that clearing or settlement transactions originated from outside the vertical chain are costly and inefficient. Therefore, in vertically integrated CMI exchange model, trades originated from alternative execution venues are cleared and settled through inefficient CCP and CSD links. Therefore, CCPs and CSDs have incentive to disintegrate from the exchange and provide services to multiple platforms. With disintegration, post trade CMIs can compensate increased cost due to disintegration from exchange by additional scale in transaction processing for alternative trade execution venues. Algorithmic trading, on the other side, increases liquidity and scale of the trade execution, therefore, exchange has less incentive to integrate more business lines to capture scale economies. However, financial market integrations as well as regulatory pressure to shift OTC trading to regulated trading venues and mandatory OTC clearing can change the incentives. In this case, vertical integration to post trade activities becomes more attractive for exchanges (Juranek and Walz, 2014). With financial integration, market size potentially increases in trade execution and post trade services.

Mandatory clearing of OTC trades at the CCPs increases market size in clearing business line. Therefore, exchanges have incentive to go for vertical integration in the value chain to utilize additional revenues from post trade services.

Rochet and Toulouse (2005) and Holthausen and Tapking (2007) touch ICSD diversification. In Rochet and Toulouse (2005) model, CSD integrates vertically with a custodian bank, which is already its member. In his one-market model, integration of CSD with custody bank reduces the transaction processing prices applied to all CSD participants. On the other side, access prices to the CSD increases for CSD participants. Therefore, marginal settlement costs are reduced; but at the same time, the number of custodian banks and competition in custodian business diminishes. In Holthausen and Tapking (2007) model, CSD diversifies organically to ICSD business. Similarly, prices reduces in social optimum but the market size of ICSD increases against custodian banks. Competing vertically integrated CSDs in a market could be remedy for the reduced competition in custodian bank services. The model depicts the formation of ICSDs in the European context. The two ICSDs in Europe, namely Euroclear and Clearstream, integrate CSD and global custodian bank functions and compete in ICSD business.

Competition of a few regional profit oriented CMIs is discussed widely, especially in the European context (Serifsoy and Weiß, 2007; Van Cayseele, 2004). In this model, a few big CMIs operating in the same market capture benefits from scale and scope economies. At the same time, availability of more than one institution provides competition and efficient pricing for the market participants as well as innovation and technological improvement. This model favors remote access, interoperability and account links and exclude vertical integration and bundling of trade and post trade services. In addition, means of state intervention in case of any default are also prohibited in order to ensure effective competition and eliminate moral hazard. Oversight and supervision of the CMIs are conduced together with state and market participants. Within this set up, cost efficient and competitive infrastructure landscape can be obtained. European landscape provides supportive and adverse evidences for this model. For trading and clearing competition of a few profit oriented CMIs proved to work in Europe. As Oxera studies reveal this model also achieves some reduction in settlement transaction costs. Still, there is room for more reduction. Competition of Euroclear and Clearstream in settlement and depository activities could not provide full market integrity at this line of the value chain. Especially integration of depository activities requires high level state intervention. Harmonization of settlement and depository function is directly linked to the harmonization of relevant national regulations at EU level. Therefore, competition of a few large CMIs could not provide a fully efficient and integrated landscape. Following CSD Regulation in 2014, a set of initiatives are taken by the EU to harmonize settlement operations and depository background across Europe. In addition, a common securities settlement platform, T2S is established by the European Central Bank to maintain efficiency in settlement operations.

4.5 Costs

US is a market with fragmented trading landscape but consolidated post trade aspects. Europe on the other side is fragmented in both trade and post trade facilities. Market integration in Europe is achieved through remote access, interoperability and account links. In European scene, many exchanges, CCPs and CSDs are competing. However, this is costly. Nera study shows that settlements cost per transaction is around 0.10 EUR in the US, but between 0.35 and 0.80 EUR in local transactions in European countries. More strikingly, cost of cross border settlement within Europe varies a lot, and could be as high as 35 EUR. Li and Marinč (2016), Köppl and Monnet (2007), Schmiedel, Malkamäki and Tarrka (2006) show that post trade transaction costs are lowest in the US.

On the other side Oxera (2011) shows that within Europe cross border transaction cost was reduced from 4.1 EUR to 2.6 EUR between years 2006 and 2009. Menkveld (2013) also shows that following the opening of Chi-X MTF in 2007, competition between EuroCCP and LCH reduced clearing costs around 50-60 % within one year. These studies confirm that market integration initiatives taken by the EU, following Giovannini Group, (2001) and G30 (2003) recommendations, became effective in reducing transaction costs. With a pan European settlement platform initiation of EU (T2S), EU further aims to reduce the settlement costs to 0.30[3] EUR (European Central Bank, 2008, 2016). Economic impact analysis further shows that a 18 % reduction in

[3] For DVP settlement trades as total of settlement fee applied to both sides of the instrucution.

post trade processing costs would pay off as 0.6 % increase in EU GDP in the following years (Schulze and Baur, 2006).

4.6 Empirical Findings on Cost and Pricing Efficiency

One of the early empirical analysis of exchange efficiency is conducted by Hasan, Malkamäki and Schmiedel (2003). They analyze the cost and revenue efficiency of 49 stock exchanges around the world with stochastic frontier models for period 1989-1998. They model total cost and total revenue as a function of price and output level as well as technological improvement over time and profit oriented organizational structure. Value of trades, number of listed companies and transaction velocity are used to proxy output levels, interactions are also considered. The results reveal that North American exchanges are most efficient in terms of both cost and revenue. European exchanges have improved over time in terms of cost efficiency. Exchanges that invest in technology have higher cost and revenue efficiency. Exchanges that operate under competition (availability of multiple exchanges or trade execution venues) increases cost efficiency and reduce revenues. They also verify that automation of the trade execution facilities and profit oriented organizational structure increase cost efficiencies.

Schmiedel, Malkamäki and Tarrka (2006) analyze 16 CSDs between years 1993-2000 and prove existence of scale economies in settlement and custody services. They use translog cost functions to define the relation between operating costs and output and price levels. They also add ICSDs and technological improvement over time into the model. Scale elasticity is calculated as output elasticity of cost with respect to number of settlement transactions and value of assets deposited at the CSD. They find that when the number of settlements are duplicated, total costs increases by 70 %, when the value of deposited securities doubled total costs increases by 18 %. Potential gains from scale economies are higher for CSDs with lower output levels. US has the maturity level of economies of scale, therefore, can be regarded as benchmark. Total costs of the CSDs reduces by 6 % over years due to technological improvements. Van Cayseele and Wuyts (2007) conduct a similar analysis for 10 European CSDs between years 1999-2004. They use settlement account numbers and number of deposited securities as proxies for the settlement and depository output levels. They find evidence for scale economies. They also find that optimal scale is obtained by 1500 settlement accounts and 25000 deposited securities. The existence of scale economies are also confirmed by Li and Marinč (2018).

Serifsoy (2007) uses data envelopment analysis to calculate cost efficiency scores for 28 exchanges around the world between years 1999-2003. Then he regresses the efficiency scores on integration (horizontal versus vertical), ownership structure (public versus private), production of technology (in-house versus outsourced) and competitiveness of the market (market liquidity and availability of international listings). The analysis provides evidence that vertically integrated exchanges are less cost efficient than others, on the other side, technological innovation is higher in vertically integrated exchanges. He concludes that product diversification and business integration of exchanges stems from motives to increase revenues and profit, not cost efficiency. Sharper (2012) uses 26 exchanges between years 2005-2008 to model effects of product diversification, horizontal and vertical integrations on average cost and profitability. Vertical integration increases cost per trade by 5 % (from 3.75 EUR to 3.93 EUR). Vertically integrated exchanges are more profitable and benefit more from economies of scale. Exchanges operating in markets where competition is maintained (existence of multiple exchanges or alternative trade execution venues), profitability is lower. These exchanges are major exchanges with high trade volume and they try to diversify their product through technology sale. No positive effects of technology sale on cost efficiency or profitability could be verified. Li and Marinč (2018) included exchanges, CCPs clearing banks, custodian banks and CSDs, total of 82 institutions for years 2010 to 2015 in the efficiency analysis. They found that efficiency increases with vertical integration and decreases with horizontal integration.

4.7 Conclusion

In this chapter, we try to provide a comprehensive literature regarding the CMI integration models with an industrial organization approach. The industrial structure of capital markets are explained analogously to network economies or public utility models. The industry is strictly regulated for financial stability and the nature of the industry is both one and two sided. Cost efficiency is achieving maximum productivity with minimum expense. Economic efficiency or price allocation efficiency indicates competitive market structure. Production functions are used to measure cost efficiency and profitability ratios to measure pricing efficiency.

Academic papers on business integration models of CMIs are few in number and diverse in findings and arguments. Theoretical models depict CMIs as profit maximizing firms and provide a game theoretic profit maximization approach. Empirical research focuses on the relation between total cost and output levels or profitability and integration model. Economies of scale and scope are evident in the CMI industry, results on integration models are diverse. Competition of a few provides the background of the horizontal mergers in Europe in early 2000s. Competition from alternative trade execution venues reduces motivation for vertical integration for exchanges. It also increases horizontal integration motive for post trade CMIs to integrate horizontally. Market integration and mandatory CCP clearing for OTC trades make the post trade integration desirable for the exchanges.

Literature focuses on either the exchanges or post trade CMIs. In addition, most of the empirical studies are based on the developed markets only. Future analysis of the industrial structure of CMIs will contribute to the literature in identifying aspects of mergers and acquisitions in terms of business integration and diversification models they bring.

5. EMPIRICAL RESEARCH ON COST AND PRICING EFFICIENCY

5.1 Introduction

In this chapter, we analyze the cost and pricing efficiency in capital market infrastructure industry with focus on business integration and diversification models applied. We analyze the effects of business integration and diversification models on overall cost as well as average costs and cost saving potential. Average costs reveal the cost structure in the short-run. Cost output scale elasticity captures the long run cost saving potential due to increased scale. Pricing efficiency is economic efficiency. We take profitability as indicator of pricing inefficiency (Sharper, 2012; Li and Marinč, 2016).

Our main research question is how asset class differentiation, vertical integration, horizontal integration and multiway integration affect short run and long run cost efficiency as well as pricing efficiency of the CMIs. The answers for these questions are relevant for designing the market and allowing, or even enforcing, domestic and global competition.

Our analysis is unique in that we evaluate both short-term and long-term effects for developed and emerging markets. We embrace different theories in CMI integration literature. Moreover, we include in our analysis all types of institutions in the capital market infrastructure value chain while previous studies focus on exchanges or CSDs only. Our results yield implications for policy makers and CMIs from both short- and long-run cost efficiency perspectives. We also consider the pricing efficiency.

In this chapter, we will summarize the literature on cost efficiency shortly, then, introduce our data and model. We will continue with the empirical findings, discussion of results and conclusion.

5.2 Literature

Academic papers on business integration models of CMIs are few in number and diverse in findings and arguments. Economies of scale and scope are available in CSDs (Malkamäki and Tarkka, 2006; Van Cayseele and Wuyts, 2007) as well as exchanges (Sharper, 2012). In addition, US post-trade infrastructure is associated with highest level of economies of scale (Malkamäki and Tarkka, 2006) and competition (Li and Marinč, 2016).

Theoretical literature is based on game theoretic profit maximization games (Kauko 2004, 2007; Rochet and Toulouse, 2005; Tapking and Yang, 2006; Holthausen and Tapking, 2007; Pirrong, 2008; Juranek and Walz, 2014). Empirical literature for cost efficiency, on the other side, is mainly based on translog cost functions (Schmiedel et al., 2006; Cayseele and Wuyts, 2007; Li and Marinč, 2016), stochastic frontier models (Hasan et al., 2003; Li and Marinč, 2016) and data envelopment analysis (Serifsoy, 2007). Economic efficiency is measured by net profit ratio (Sharper, 2012), Lerner Index and Boone Indicator (Li and Marinč, 2016).

Literature is diverse about the effect of vertical integration on efficiency. Pirrong (2008) and Tapking and Yang (2006) argue vertical consolidation of trade and post-trade services reduces costs. Accordingly, vertical integration prevents double margining and provides economies of scope. Both models favor competing vertically integrated silos in order to achieve efficient price allocation. However, empirical studies show vertical integration reduces cost efficiency (Serifsoy, 2007), increases profitability (Sharper, 2012) and decreases competition (Li and Marinč, 2016).

Vertical integration and asset class differentiation of exchanges mostly stem from the motivation to increase revenues rather than achieving cost reductions. So, regulators and CMIs have different motivations in choosing integration models (Sharper, 2012; Serifsoy, 2007). Furthermore, Köppl and Monnet (2007) advocate that vertical integration of exchanges is a barrier against efficient exchange consolidation. Price of post-trade services is private information for vertically integrated exchanges; therefore, they cannot agree on true cost of clearing and settlement. Polato and Floreani (2008) mention concerns about possible abuse of dominant position and risk of discrimination in access when exchanges integrate vertically down in value chain.

We believe that diverse findings regarding the effects of vertical integration stems from the different effects of vertical integration in the short run and in the long run, as well as on pricing power. Theoretical models focus on the hypothetical long run efficiency, while empirical studies reveal contemporaneous or short run effects.

Regarding horizontal integration, we hypothesize that it increases cost efficiency in the short run as it allows the best technology of the merged or consolidated markets to be put in place. We assume that gains from horizontal integration is realized initially at the early years of integration. Gains from horizontal integration depend on the cost of technology transfer (Tapking and Yang, 2006). Horizontal integration increases global competition (Li and Marinč, 2016). This is mainly due to the fact that horizontal integration creates competing global networks.

We hypothesize that as it is combination of horizontal and vertical integrations, multiway integration has positive effects on cost efficiency in the short and long run. Tapking and Yang (2006) showed that vertical integration in one market and horizontal in the other has the highest cost saving potential in their two-country model.

As the industry is associated with high fixed costs and limited entry, competition of a few large CMIs is favored, especially in European context. Competition of a few would achieve both efficient price allocation and cost efficiency as it embodies economies of scale and scope (Serifsoy and Weiß, 2007; Van Cayseel, 2004). CCPs and CSDs are not in long-run equilibrium (Li and Marinč, 2016).

5.3 Data

Our data cover 34 institutions (exchanges, clearing houses/CCPs and CSDs) from 22 countries between years 2010 and 2016. All institutions are from Bank of International Settlements Committee on Payments and Market Infrastructures (BIS- CPMI) countries.

Data is obtained from BIS-CPMI Redbook, European Central Securities Depositories Association (ECSDA) statistics, World Federation of Exchanges (WFE) statistics and entities' financial and activity reports available on their official internet sites.

Description of variables and data sources are presented in Table 5.1. Dimension indicates the variable group, which measure a specific concept. Efficiency measures are the dependent variables for which we analyze the effects of the other (independent)

Table 5.1 : Variables.

Dimension	Variable	Definition	Source
Efficiency measures	Ln TC	Natural logarithm of total operating cost in million USD	Entities' annual reports
	AC	Average cost per transaction (USD)	Estimated with the expansion path and average cost model described in "Methodology" section
	scale	Scale coefficients	Estimated from total cost model described in "Methodology" section
	NPR	Ratio of Net income before tax to Total operating revenue (NI/TR)	Entities' annual reports
Output and price levels	Ln Q_{sec}	Natural logarithm of number of securities transactions in millions	BIS CPMI, ECSDA, WFE, entities' reports
	Ln Q_d	Natural logarithm of number of derivatives contracts in millions	BIS CPMI, ECSDA, WFE, entities' reports
	Ln P	Natural logarithm of Price level calculated as GDP per capita (USD) in operated countries in	World Bank
Size	Ln GDP	Natural logarithm of gross domestic product (USD) adjusted for Purchasing Power Parity of countries where the entity is operating	World Bank
	Ln TA	Natural logarithm of total assets in million USD	Entities' annual reports
Business Integration Model (BIM)	indep	Dummy for Independent, non integrated CMIs	BIS CPMI, ECSDA, WFE, entities' reports
	horiz	Dummy for horizontal integration	BIS CPMI, ECSDA, WFE, entities' reports
	vert_exccp	Dummy for vertical integration of exchanges with CCPs	BIS CPMI, ECSDA, WFE, entities' reports
	vert_silo	Dummy for silo model vertical integration	BIS CPMI, ECSDA, WFE, entities' reports
	multi	Dummy for multiway integration	BIS CPMI, ECSDA, WFE, entities' reports
Diversification (DIV)	diff	Dummy for asset class differentiation	BIS CPMI, ECSDA, WFE, entities' reports
	ICSD	Dummy for CSD with global custodian bank functions	BIS CPMI, ECSDA, WFE, entities' reports
	data	Dummy for data and information services	Entities' annual reports
	dex	Dummy for sole specialized derivatives exchanges	BIS CPMI, ECSDA, WFE, entities' reports

Table 5.1 (continued): Variables.

Dimension	Variable	Variable Definition	Source
Region (REG)	reg_us	Dummy for CMIs operating in the USA	BIS CPMI, WFE, entities' reports
	reg_eurp	Dummy for CMIs operating in Europe	BIS CPMI, WFE, entities' reports
	reg_ap	Dummy for CMIs operating in Asia Pacific	BIS CPMI, WFE, entities' reports
	reg_india	Dummy for CMIs operating in India	BIS CPMI, WFE, entities' reports
Type	exch	Dummy for exchanges	BIS CPMI, ECSDA, WFE, entities' reports
	CSD	Dummy for Central Securities Depositories	BIS CPMI, ECSDA, WFE, entities' reports
Developed vs Emerging market	bo	Dummy for beneficial owner basis markets	BIS CPMI, ECSDA, WFE, entities' reports
Technological improvement	time	Time trend for years 2012-2016, Z [0,1]	-

Entities' financial reports are obtained from entity internet sites or for US Securities Exchange Commission Forms. Other reports regarding entities' activities are obtained from their official internet sites. BIS CPMI Red Book is the yearly statistics book published by Bank of International Settlements Committee on Payments and Market Infrastructures. ECSDA is the European Central Securities Depositories Association; WFE is World Federation of Exchanges. Z: integer.

variables. Efficiency measurement variables are log total cost (Ln TC), average cost per transaction (AC), scale coefficients (scale) and net profit ratio (NPR). Average cost and scale are estimated with the models described in the Methodology section. Net profit ratio is the ratio of net income before tax (NI) to total operating revenue (TR).

Total cost (TC) indicates total operating cost. Total cost, net income before tax (NI), total revenues (TR) as well as total assets (TA) data are obtained from CMI's official annual financial reports disclosed at their corporate internet pages.

Output and price level variables include log number of securities transactions (Ln Q_{sec}), derivatives contracts (Ln Q_d) processed and log GDP per capita (price level- Ln P). Number of securities transactions (Q_{sec}) is the total number of trades executed, transactions cleared and settled in millions. For settlement to keep the consistency with trade execution and clearing figures, pre-settlement (not netted) figures are used. Number of derivatives contracts (Q_d) is the total of trades executed and transactions cleared in millions. GDP per capita is used as proxy for price level (P) (Hasan et al., 2003; Schmiedel et al., 2006; Cayseele and Wuyts, 2007; Li and Marinč, 2016). It is calculated as total GDP of the operating countries divided by total population of operating countries. For number of securities transactions and derivatives contracts, BIS CPMI Redbook statistics are used. When the data is not obtainable from BIS CPMI, then WFE and ECSDA data is used. Data is cross checked for compatibility. Gross Domestic Product (GDP) and population data are obtained from World Bank database. GDP and total assets (TA) are used as proxy for economy size and entity size. GDPs of the countries in which the CMIs have operations are included.

Business integration model (BIM) dimension includes no integration (independent, indep), horizontal integration (horiz), vertical integration of exchanges and CCPs (vert_exccp), vertical integration of whole value chain in silo model (vert_silo) or both horizontal and vertical integration (multi). Independent CMIs (indep) are those that are not diversified or integrated. Horizontal integration (horiz) is the consolidation of trading platforms for exchanges, providing clearing or settlement services to multiple markets for CCPs and CSDs. Vertical integration is consolidation of business units back in capital market infrastructure value chain. Vertical integration is classified in two sections: (1) vert_exccp indicates vertical integration of exchanges with CCPs, and (2) vert_silo indicates vertical integration of whole value chain.

Silo model vertically integrated CMIs are usually national silos. Multiway integration (multi) embodies both horizontal and vertical integration. CMIs are regarded as integrated if they have a consolidated management. Providing a consolidated financial statement is assumed to be the indicator of consolidated management. Account links and other ways of interoperability or cooperation are not regarded as business integration. In some cases, CMIs operate under joint ventures or have shares in other CMIs. These CMIs are regarded as non-integrated unless they have consolidated financial statements.

Product diversification (DIV) dimension includes asset class differentiation (diff), ICSD diversification (ICSD), diversification to data and information business (data) and providing infrastructure solely to derivatives (dex). Diversification dimension includes the attempts of CMIs to increase their business scope. For exchanges and CCPs that provide services for multiple asset classes, asset class differentiation (diff) is available. Exchanges may undergo asset class differentiation by opening or acquiring new trading platforms; i.e. a stock exchange having also a derivatives trading platform. CCPs might go product differentiation by providing clearing services to different asset classes such as equities, exchange traded derivatives and OTC derivatives. All CSDs are undifferentiated as they provide securities settlement services. CSDs that provide cross border settlement and global custody services in multiple markets together with related banking services are ICSDs. Euroclear, DBG-Clearstream and SIX SIS are regarded as ICSD. ICSDs structure is regarded as diversification of CSD services to global custodian bank services.

Four major regions are chosen to capture the effect of region-specific factors such as jurisdictions and specific market practices. United States (reg_us), Europe (reg_eurp) Asia Pacific (reg_ap) and India (reg_india) are region variables. Europe includes United Kingdom (UK), Ireland, France, the Netherlands, Belgium, Italy, Portugal, Germany, Luxembourg, Sweden, Norway, Denmark, Finland and Switzerland. Asia Pacific countries are Singapore, Hong Kong, Korea, Japan and Australia. India is regarded as a separate region due to its significantly low cost and special case of two vertically integrated CMI existence. Rest of the CMIs (BmfBovespa of Brazil, TMX Group of Canada, MOEX of Russia, BIST, Takasbank and MKK of Turkey, JSE and Strate of South Africa, Tadawul of Saudi Arabia) remain in the comparison group. Entity types are exchanges (exch), CCPs and CSDs.

Market beneficial ownership type (bo) is used as a proxy of available CMI competition as well as distinction of developed and emerging markets. In our data, all beneficial owner markets are regarded as emerging markets. In these markets, trade execution is centralized in one exchange and investor level account segregation is required at CSD level. Legal and beneficial ownership concepts are not recognized, therefore, the account owner in the CSD is both legal and beneficial owner of the securities held in that account. All non-beneficial owner markets in our dataset are regarded as developed markets. In these markets beneficial owner market structure is not applied and nominee account structure is recognized. Therefore, CSD accounts are the top tier accounts that shows the legal ownership. Beneficial ownership remains in the books of custody intermediaries, transfer agents or registrars. Trading is fragmented among exchanges and other trading venues. Therefore, there is competition in trade execution. Although market share (and therefore market power) of the fragmented trading venues varies, at least regulatory setting is in place for competition in all non-beneficial ownership markets. For CMIs that operate under beneficial owner market structure, “bo” variable equals to 1, for others 0. In the remainder of the dissertation, beneficial owner markets indicate emerging markets and non-beneficial owner markets indicate developed markets.

Table 5.2 provides summary of the data. CMI type, business integration and diversification models, market beneficial ownership type as well as total cost, total revenue, net income before tax, total assets, GDP, price level, number of securities transactions and number of derivatives contracts processed are presented.

Out of 34 institutions in our study, 22 are exchanges, 4 are CCPs and 8 are CSDs. The relatively high number of exchanges is due to the fact the vertical and multiway integrated groups are regarded as exchanges. For example, Deutsche Börse Group (DBG) is regarded as exchange and it includes a securities (Xetra) and derivatives (Eurex) exchange as well as a CCP (Eurex Clearing). London Stock Exchange Group (LSEG) operates exchanges (London Stock Exchange, Borsa Italia) as well as CCPs (LCH and CCG), and a CSD (Italian CSD- Monte Titoli). Both regarded as differentiated and multiway integrated exchanges. DBG and SIX groups’ ICSD functions are presented separately. Euroclear, DBG-Clearstream and SIX SIS are regarded as ICSD.

11 CMIs work in beneficial owner markets, 19 have product differentiation. 8 CMIs are horizontally, 16 vertically, 8 multiway integrated and 2 are independent. Out of 16 vertically integrated CMIs, 13 are vertically integrated in silo model and 3 are vertically integrated exchanges with CCPs.

Most Asia Pacific and emerging markets have a vertically integrated national silo model (ASX, BmfBovespa, TMX Group, HKEX, BSE Group, SGX, KRX, Borsa Istanbul, MOEX, SIX and Tadawul). These national exchanges (except Tadawul) also utilize product differentiation, handling both securities and derivatives services at one body. In some markets, exchanges are integrated with the CCP but not the CSD. NSE of India, JSE of South Africa, TFX of Japan are of this type. In these markets, CSDs are usually horizontally integrated and provide services to multiple exchanges and trading platforms.

Horizontally integrated CMIs are Euronext, Euroclear, National Securities Depository of India (NSDL), Japan Securities Depository Cooperation (JASDEC), CSD of South Africa (Strate), EuroCCP and Options Clearing Corporation of US (OCC). Euronext consolidates exchanges of Amsterdam, Paris, Brussels and Lisbon under single order book. OCC is the US clearing house and CCP that provides horizontally integrated services to 15 derivatives exchanges. Pan-European EuroCCP horizontally integrate the clearing of securities from 20 European markets traded in 25 alternative trading platforms and have direct central bank links to several European central banks as well as T2S. JASDEC and Strate horizontally integrate the settlement and custody activity in their region. DTCC is horizontally integrated in US region and vertically integrated in post trade value chain. Two competing regional horizontally integrated CSD groups of Europe, Euroclear and Clearstream, provide CSD and ICSD services. Euroclear operates CSDs in France, Netherlands, Belgium, UK& Ireland and Sweden as well as one ICSD. Clearstream is a subsidiary of DBG operates in Germany and Luxemburg. DBG and LSEG are two big competitors in European CMI framework.[4] US originated ICE Group and Nasdaq are globally integrated, mostly in exchange and clearing business lines. Their CSD business lines are so small and can be ignored. CME Group (former Chicago Mercantile Exchange) focuses on derivatives trading and clearing and remains undifferentiated. Japan Exchange Group (JPX) consolidates Tokyo and Osaka

[4] Consequently, their merger proposal was rejected by European Commission in 2017.

Table 5.2 : Data (2012-2016 average).

Entity	Type	BIM	DIV	bo	TC (million USD)	TR (million USD)	NI (million USD)	TA (million USD)	GDP (billion USD)	P (thousand USD)	Qsec (million)	Qd (million)
BmfBovespa (Brazil)	exch	vert_silo	diff	1	341.51	847.06	705.62	10,378.24	3,196.78	15.66	620.96	114.63
TMX Group (Canada)	exch	vert_silo[1]	diff	0	329.55	540.21	96.32	14,735.92	1,571.52	44.25	614.93	222.48
ASX (Australia)	exch	vert_silo	diff	0	256.23	723.45	460.70	5,574.07	1,066.44	45.37	657.88	459.42
JPX (Japan)	exch	multi	diff[2]	0[3]	540.63	1,006.83	481.01	183,325.00	5,049.33	39.67	1,331.80	642.12
TFX (Japan)	exch	vert_exccp	-	0[3]	76.25	72.93	6.16	3,764.09	5,049.33	39.67	-	105.01
JASDEC (Japan)	CSD	horiz	-	0[3]	156.45	193.96	37.80	702.00	5,049.33	39.67	684.38	-
HKEX (Hong Kong)	exch	vert_silo	diff	0	372.25	1,194.38	830.44	20,596.13	399.88	55.23	782.48	577.25
KRX (Korea)	exch	vert_silo	diff	1	828.40	607.65	208.31	9,716.18	1,725.71	34.01	4,268.34	1,886.14
SGX (Singapore)	exch	vert_silo	diff	1	257.34	558.19	301.20	1,389.62	456.45	83.46	106.14	267.88
DBG- Clearstr. (Ger, Lux)	CSD	multi	ICSD	0	734.73	1,089.30	342.73	85,230.76	3,835.23	46.87	189.32	-
DBG- Clearstr. Excl. (Ger)	exch	multi	diff	0	1,094.73	1,917.36	744.50	148,514.51	3,835.23	46.87	340.23	4,509.29
EuroCCP (Neth.)	CCP	horiz	-	0	17.05	21.88	3.63	532.99	823.96	48.81	1,296.54	-
Euroclear (pan Europe)	CSD	horiz	ICSD	0	1,105.59	1,373.02	376.23	27,270.00	7,523.89	42.06	1,124.84	-
Euronext (pan Europe)	exch	horiz	diff	0	357.03	604.22	239.23	999.53	4,022.50	42.51	201.11	1,169.54
LSEG (pan Europe)	exch	multi	diff, data[4]	0	936.25[4]	1,567.26	557.07	377,525.70[4]	8,790.66	40.05	1,685.69	524.20
SIX Swiss Exchange	exch	vert_silo	-	0	137.60	208.78	90.67	630.65	503.56	61.48	41.59	-
SIX SIS (Swiss)	CSD	vert_silo	ICSD	0	146.84	175.39	56.31	6,093.91	503.56	61.48	57.53	-
SIX x-clear (Swiss)	CCP	vert_silo	-[5]	0	16.75	13.21	(6.53)	1,080.67	503.56	61.48	311.87	1.96
BSE (India)	exch	vert_silo	diff	1	56.55	52.77	32.51	709.41	7,398.20	5.71	1,320.82	249.11
NSE (India)	exch	vert_exccp	diff	1	112.03	241.96	220.52	2,221.57	7,398.20	5.71	3,385.71	4,520.15
NSDL (India)	CSD	horiz	-	1	17.54	25.62	13.95	81.26	7,398.20	5.71	1,693.32	-
MOEX (Russia)	exch	vert_silo	diff[6]	1	251.07	353.98	474.08	25,957.84	3,695.54	25.70	307.44	476.40

Table 5.2 (continued): Data (2012-2016 average).

Entity	Type	BIM	DIV	bo	TC (million USD)	TR (million USD)	NI (million USD)	TA (million USD)	GDP (billion USD)	P (thousand USD)	Qsec (million)	Qd (million)
JSE (South Afr.)	exch	vert_exccp	diff	0[3]	95.16	166.83	77.79	239.97	704.78	12.92	98.96	6.73
Strate (South Afr.)	CSD	horiz	-	0[3]	22.60	33.19	11.91	41.12	704.78	12.92	49.62	-
Tadawul (Saudi Arab.)	exch	vert_silo	-	1	88.64	106.05	39.40	911.90	1,617.09	52.57	98.76	-
BIST (Turkey)	exch	vert_silo[8]	diff[7]	1	129.15	205.05	88.05	1,372.64	1,806.62	23.41	241.55	120.35
Takasbank (Turkey)	CCP	horiz[8]	diff	1	25.52	26.78	56.28	2,048.33	1,539.11	20.64	81.52	75.89
MKK (Turkey)	CSD	indep[8]	-	1	20.05	28.55	9.46	41.13	1,539.11	20.64	79.93	-
ICE (USA, Europe)	exch	multi	diff, data[8]	0	1,234.30[8]	3,338.59	1,276.54	63,568.24[8]	17,403.92	54.61	1,847.34	3,341.36
Nasdaq (USA, Europe)	exch	multi	diff	0	1,262.40	2,000.60	501.60	11,958.20	18,037.62	53.85	2,325.73	1,185.61
CBOE (USA)	exch	indep	dex	0	318.62	613.70	293.31	405.17	17,403.92	54.61	-	1,201.17
CME Group (USA)	exch	multi	dex	0	1,413.20	3,177.08	1,862.04	60,424.68	17,403.92	54.61	-	6,783.71
OCC (USA)	CCP	horiz	-	0	195.49	225.49	37.55	7,223.70	17,403.92	54.61	-	4,184.87
DTCC (USA)	CSD	multi	-	0	1,329.80	1,411.30	93.01	27,676.03	17,403.92	54.61	41,403.68	-

Entity types are exchanges (exch), central counterparties (CCP), central securities depositories (CSD). Business integration models (BIM) are no integration (indep), horizontal (horiz), vertical exchange and CCP (vert_exccp), vertical silo (vert_silo) and multiway (multi) integrations. Business scope diversification (DIV) variables are asset class differentiation for exchanges and CCPs (diff), data and information services diversification (diff), ICSD diversification (ICSD) and sole derivatives exchanges (dex). Bo is the market beneficial ownership type; it takes value 1 for markets where end investor accounts are segregated at CSD level. Total cost (TC), total revenue (TR), net income before tax (NI) and total assets (TA) are in million USD. GDP is the gross domestic product of countries in which the entity is operating, indicated as billion USD. P is the price level measured by per capita gross domestic product in countries where the entity has operations, indicated in thousand USD. Qsec is the number securities transactions processed in millions. Qsec is the number of derivatives contracts processed in millions. All values are average of years 2012-2016. Operating countries are indicated in parenthesis, although some have pan regional/global reach. Geographical dispersion is captured by horizontal or multiway integration variable. Lux : Luxembourg, Neth: the Netherlands, Swe. Sweden, Swiss: Switzerland, UK: United Kingdom. ASX: Australian Stock Exchange, HKEX: Hong Kong Stock Exchange, BSE: Bombay Stock Exchange Group, NSE: National Stock Exchange Group, NSDL: National Securities Depository Limited, JPX: Japan Exchange Group, TFX: Tokyo Financial Exchange, JASDEC: Japan Securities Depository Corporation, KRX: Korea Exchange, MOEX: Moscow Exchange Group, SGX: Singapore Stock Exchange, DBG: Deutsche Börse Group, LSEG: London Stock Exchange Group, JSE: Johannesburg Stock Exchange, BIST: Borsa Istanbul, Takasbank: CCP of Turkey, MKK: CSD of Turkey, ICE Group: Intercontinental Exchange Holdings, OCC. Options Clearing Corporation, DTCC: Depository Trust Clearing Corporation. [1] TMX Group became vertically integrated silo as it acquired Canada's CSD in July 2012. Before the acquisition the Group was differentiated exchange with CCP integration. [2] Tokyo Stock Exchange merged with Osaka Exchange and formed JPX in January 2013. With the merger the group extends its vertical exchange and CCP integration to multiple markets and became both horizontally and vertically integrated. [3] In Japan and South Africa account segregation at beneficial investor level is required at authorized intermediary custodian level, not at CSD level. [4] LSEG acquired data business in 2014. Total costs and total assets attributed to data and information services business segments are excluded in years 2014, 2015 and 2016.[5] SIX x-clear is differentiated to derivatives after merger with Oslo Clearing ASA in 2016. [6] MICEX Securities Exchange differentiated by merger of RTS Derivatives Exchange in December 2011. The group went public in 2013 as MOEX. [7] Borsa İstanbul merged with Turkish Derivatives Exchange and Istanbul Gold Exchange in 2012. Consolidation process with the CCP and CSD of Turkey under Borsa Istanbul began as of 2013. The group is rebranded as Borsa Istanbul in 2013. Figures for Takasbank and MKK is for year 2012 only. [8] ICE acquired data business in 2016. Total costs and total assets attributed to data and information services business segments are excluded in year 2016.

exchanges horizontally and vertically integrated with the CCP. TFX, NSE Group and JSE are exchanges vertically integrated the CCP business line. Today, a few CMIs remain independent. Among those in our dataset, Chicago Board Options Exchange (CBOE) has been regarded as independent, however it recently acquired BATS Global Exchange and formed a differentiated and horizontally integrated exchange group in 2017[5].

In order to match costs and outputs in the same manner for all CMIs, product diversification to the field of data and information services are excluded from the data to be used in cost analysis. We regard number of transactions or contracts as output variables for transaction processing function of CMIs, not output for data and information business lines. LSEG data after 2014 and ICE data after 2016 is amended so that total costs and total assets does not include costs and assets related to data and information services business segments. For SIX Group, only exchange and post-trade securities services segments are included in the analysis.

Our dataset covers 55% of world equities transactions and 80% of world derivatives contracts processed. Our regional coverage is over 50% for all the WFE regions (WFE Statistics, 2017). For bonds, only 7% of world bond trade transactions are represented in our data, however considering the off-exchange wholesale nature of bonds, clearing and settlement transaction coverage is representative. Our data include institutions, which settle a vast majority of European and US non-government bonds corporate bonds and Eurobonds. These are Euroclear and Clearstream of Europe and DTCC of US. Securities transactions includes equity and bond transactions. Therefore, we believe our coverage is satisfactory and our dataset is representative for both securities and derivatives transactions.

5.4 Methodology

In this research we try to recognize and explore how asset class differentiation, vertical integration, horizontal integration and multiway integration affect short run and long run cost efficiency as well as pricing efficiency of the CMIs. Our hypotheses are as follows. (1) Economies of scale is available; (2) horizontal integration increases short

[5] We regard CBOE independent and undifferentiated in this study since our data is prior to 2017.

run cost efficiency; (3) vertical integration decreases short run cost efficiency but increases long run cost efficiency; (4) multiway integration increases short run and long run cost efficiency; (5) economies of scope is available, i.e., product differentiation increases cost efficiency in the short and long run; (6) integration and product diversification increase profitability.

In order to test these hypothesis, we first measure technical, short-run and long-run cost efficiency as well as pricing efficiency. Then we regressed them on our independent variables, which construct our integration and diversification framework.

Cost efficiency is achieving maximum productivity with minimum wasted expense by definition. In the CMI industry output levels are exogenously determined (Hasan et al., 2003; Schmiedel et al., 2006; Cayseele and Wuyts, 2007; Serifsoy, 2007; Sharper, 2012; Li and Marinč, 2016), thus, cost reduction is key to increase cost efficiency.

For the analysis of cost efficiency, we first estimate total cost function. In the estimation of total cost, we include business integration model, diversification, region, entity type and time trend as well as quantities and price level. Analysis of total cost function shows contemporaneous cost structure of CMIs. It shows the technical efficiency component, which is the cost reduction capacity of the CMIs independent of scale, scope and other variables included in the model. We estimate model parameters with time-varying decay inefficiency model (panel data stochastic frontier model).

Then, we turn our analysis to average transaction cost to see short run cost per unit cost structure. In order to estimate average cost, we aggregate our securities and derivatives quantities per market. We use an expansion path between number of securities transactions and derivatives contracts processed per market. Then we use this path in estimating securities transaction equivalent quantity of derivatives contracts processed by the CMIs. Average cost shows the short run nature of the cost.

We further analyze scale elasticity coefficients derived from the total cost function in order to see long run cost saving potential utilized due to increased output scale. From the translog total cost function we derive cost output elasticity of output quantities and we estimate scale elasticities.

In order to measure pricing power of the CMIs we use net profit ratio (NPR). Net profit ratio is the profit before tax divided by revenues. The lower values indicated less pricing power and more competitive market structure.

We regress our business integration model and diversification variables as well as geographical region, entity type, entity size and time trend on average cost, scale elasticity and profitability. We use market beneficial ownership type as control variable.

5.4.1 Total Cost Function and Technical Efficiency

To measure long-run cost efficiency, we estimate cost function for CMIs, and then predict inverse cost elasticity of outputs. In line with Li and Marinč (2016), Schmiedel et al. (2006) and Cayseele and Wuyts (2007), we use the following translog cost function given in equation (5.1a) and (5.1b).

$$
\begin{aligned}
& LnTC\big(LnQ_{secit},\ LnQ_{dit}, LnP_{it},\ BIM_{kit}, DIV_{lit}REG_{mit}, TYPE_{nit}, C_{pit}\ , time \\
& = a_0 + a_{11}\ln Q_{secit} + a_{12}\ln Q_{dit} + a_{21}(\ln Q_{secit})^2 + a_{22}(\ln Q_{dit})^2 \\
& + a_{31}\ln Q_{secit}\ln Q_{dit} + a_{41}(\ln P_{it})^2 + a_{42}\ln P_{it} + a_{43}\ln P_{it}\ln Q_{secit} \\
& + a_{44}\ln P_{it}\ln Q_{dit} + \sum_k a_{5k}\, BIM_{kit} + \sum_l a_{6l}\, DIV_{lit} + \sum_m a_{7m}\, REG_{mit} \\
& + \sum_n a_{8n}\, TYPE_{nit} + \sum_p a_{9p}\, C_{pit} + a_{10}time - v_{it} + e_{it}
\end{aligned}
\tag{5.1a}
$$

$$
v_{it} = \exp\{-\eta(t - T_i)\}\, v_i \tag{5.1b}
$$

The model variables are explained in Table 5.1. In the model, log total operating cost (Ln TC) is a function of log output quantities (Ln Q_{sec}, Ln Q_d),log price level (Ln P), business integration model (BIM), diversification aspects (DIV) geographical region (REG), entity type (TYPE) and exogenous control variables (C). Quantity consists of two variables: log number of securities transactions processed (Ln Q_{sec}) and log number of derivatives contracts processed (Ln Q_d). Gross domestic product per capita (P) shows price level. Quadratic and interaction terms are included in the model. Business integration model (BIM) variables include product horizontal integration (horiz), vertical integration of exchanges with CCPs (vert_exccp), vertical integration in silo model (vert_silo) and multiway integration (multi). Diversification aspects (DIV) include asset class differentiation (diff) for exchange and CCPs and ICSD formation for CSDs. Geographical region variables (REG) are US region (reg_us), Europe (reg_eurp), Asia Pacific (reg_ap) and India (reg_india). Region variables captures the effects such as regulatory background and market practices. Entity types (TYPE) are exchange (exch), CCPs and CSDs. Exogenous control variables (C) are market beneficial ownership type (bo) and log size of the economy where the institution is operating (Ln (GDP)). Gross domestic product (GDP) indicates economy size. Linear time trend (time) is also added to see any trend related to time or technology progress. Total operating cost, output quantities and price levels as well as size variables are transformed to natural logarithm. Entities are indicated with *i* and time with *t*.

We employ random effect panel stochastic frontier regression to estimate the model parameters (Li and Marinč, 2016). $e_{it} \sim N(0, \sigma_{eit}^2)$ is the idiosyncratic error component. υ_{it} is the technical inefficiency term that depends on time invariant entity specific technical inefficiency (υ_i) and time (t). The relation with time is determined with an exponential function. T_i is the last period of i^{th} entity and η is the time decay parameter. The last period contains the base level of inefficiency as in the last period $t = T_i$ and $\upsilon_{it} = \upsilon_i$. If $\eta > 0$, the degree of inefficiency decreases over time toward the base level. If $\eta < 0$, the degree of inefficiency increases over time to the base level. If $\eta = 0$, the degree of inefficiency is time invariant. $\upsilon_i \sim N^+(\mu, \sigma_\upsilon^2)$ is entity-specific time-invariant technical inefficiency. This distribution assumes that negative inefficiency is efficiency; therefore, they are not regarded in the distribution of inefficiency term. Model coefficients for time decay parameter (η) expected inefficiency component (μ), variance of idiosyncratic error term (σ_e) and variance of technically inefficiency term (σ_υ) are estimated by maximum likelihood function (Kumbhakar and Lovell, 2000).Technical inefficiency term indicates the inefficiency component independent of scale, scope, integration, diversification, region, type and other control variables.

We also estimated model parameters with standard random effects GLS regression (Schmiedel et al. 2006). The sign and significance of the output coefficients remain same, with some alterations. Comparison of coefficients for frontier and GLS models are presented in Table A.1 (Appendix A). The main advantage of frontier panel data model over random effects GLS models is that it models the technical inefficiency term. Random effect GLS regressions assumes that the entity level error (or inefficiency) component (u_i) has normal distribution with mean zero. However, panel data frontier model allows technical inefficiency term (υ_{it}), which is modeled with time (T_i) and a time invariant component (υ_i). The time invariant component captures the negative efficiency as inefficiency only. Thus, the frontier models are widely used in banking literature (e.g. Fu et al. 2014; Koetter et al. 2012) to estimate the cost function as they provide a more detailed picture. Therefore, we also preferred to use the frontier model. Hausman test for fixed or random effects, Lagrange Multiplier test for random effects, likelihood ratio test for model variables, unit root and serial correlation tests are also conducted as diagnostics in Appendix A.

5.4.2 Short-Run Costs

Cost per transaction is a general measure of cost efficiency in CMIs. However, due to multi-service environment it is difficult to determine cost per transaction easily. Literature that focuses on cost efficiency has different approaches. Sharper (2012) used cost per trade transaction for exchanges, while Schmiedel et al. (2006) and Cayseele and Wuyts (2007) use Ray scale elasticity of total cost as a measure of unit cost saving potential. On the other hand, Serifsoy (2007) adopts data envelopment analysis.

In our two-output model, we use Ray average cost approach to estimate average cost per output type. Following Schmiedel et al (2006) and Baumol et al (1988), we use a function that defines the relationship between output types at market level. In order to use expansion path between number of securities transactions and number of derivatives contracts, we had to aggregate our data per market, since not all entities have the two type of outputs but all markets do have. It is meaningful to relate these two types of outputs per market since depth in one asset class is associated with the development of the other in a market. Expansion path function that we get from per market data enables us to express number of derivatives contracts processed in a market in terms of number of securities transactions processed in that market. Feasible Generalized Least Square (FGLS) regressions used to control for autocorrelation, cross sectional dependence and heteroscedasticity in panels. As we applied the path to entity level data, we consequently reduce our output types to one type. So that, we can divide total cost to this output level in order to get average cost of a securities transaction or securities transaction equivalent derivatives contract.

We used random effects panel data regression to analyze the effects business integration model (BIM_k), namely, no integration (indep), horizontal integration (horiz), vertical integration of exchanges with CCPs (vert_exccp), vertical integration in silo model (vert_silo), and multiway integration (multi) on average cost. Diversification variables are asset class differentiation (diff), and ICSD. Geographical regions (USA, Europe, Asia Pacific and India), entity types (exchange, CSD), entity size (log total assets), market beneficial ownership type (bo) and linear time trend is also included (time) are also included in the model. The model is presented in Equation 5.3.

$$
\begin{aligned}
AC_{it} = \beta_0 + \sum_k \beta_{1k}\, BIM_{kit} + \sum_l \beta_{2l}\, DIV_{lit} + \sum_m \beta_{3m}\, REG_{mit} \\
+ \sum_n \beta_{4n}\, TYPE_{nit} + \beta_5 Ln(TA) + \sum_p \beta_{6p}\, C_{pit} + \beta_7 time \\
+ \ u_i + e_{it} \qquad (5.3)
\end{aligned}
$$

We employ random effect GLS regression to estimate the model parameters (Baltagi 2013; Wooldrige 2013). $u_i \sim N(0, \sigma_{uiF}^2)$ is entity-specific time-invariant error term and $e_{it} \sim N(0, \sigma_{eit}^2)$ is the idiosyncratic error component. Huber/White/sandwich heteroscedasticity-corrected standard errors are used for potential heteroscedasticity of error terms. Diagnostic tests for fixed and random effects, cross sectional dependence, serial correlation and unit roots are conducted in Appendix B. Nevertheless cross sectional dependence and serial correlation is problematic for panels with long time series more than 20 years. For micro panels for a few years, these does not cause big problems, the analysis is robust against these assumptions for micro panels (Baltagi 2013).

Market beneficial ownership type affects the possible business integration models that CMIs can adopt. For example, in emerging markets, the opportunities of integration are limited within national borders. In addition, most of the previous literature focuses on developed market exchanges or CSDs. Therefore, analysis is repeated for the market beneficial ownership and entity type subgroups. In previous literature all analysis is conducted on developed markets, such as Sharper (2012), Schmiedel et al. (2006), Cayseele and Wuyts (2007), Serifsoy (2007), and Pirrong (2008). Hence, the analysis of beneficial owner and non-beneficial owner markets provides comparison with previous literature. It also provides robustness checks for the results.

5.4.3 Long-Run Costs and Economies of Scale

In firms' economics literature, economies of scale are associated with the long run cost structure. As the scale of operations expands, firms move to long-run cost structure (Tirole, 1988). Therefore, we admit that utilization of economies of scale measures long-run cost saving potential. As CMIs have higher economies of scale, they have lower costs in the long-run.

Following Schmiedel et al (2006) and Cayseele and Wuyts (2007), we estimate output scale elasticity of total cost. Scale elasticity coefficients show utilization of the unit cost saving potential as the output levels increase. As our production function is translog, we get cost output elasticity (ε_{sec} and ε_d) by taking partial derivatives of log total cost (Ln TC) with respect to log outputs (Ln Q_{sec} and Ln Q_d). For estimation, we use the significant coefficients of quantity terms in our translog cost function at 95 % confidence level. For robustness check regressions are repeated with ε_{sec} and ε_d estimated by all coefficients of quantity terms .

$$\varepsilon_{sec,it} = \frac{\partial \ln (TC_{it})}{\partial \ln(Q_{secit})}, \qquad \varepsilon_{d,it} = \frac{\partial \ln(TC_{it})}{\partial \ln(Q_{dit})} \tag{5.4}$$

In what follows, utilization of scale economies for two outputs are estimated by Ray scale elasticity coefficient (scale elasticity), which is sum of cost output elasticity of securities (ε_{sec}) and derivatives (ε_d). If the scale elasticity is greater than one, then the entity is operating with decreasing returns to scale. Costs increase more than 1 % if outputs increase by 1%. Economies of scale is overused and optimal output scale has been passed. There is no cost saving potential by increasing the output scale. If the scale elasticity is less than one, then the entity is operating with increasing returns to scale, which means that there is further cost saving potential to be utilized by increasing the scale of outputs. If the scale elasticity is equal to one, then the entity is operating under optimal scale given its current cost structure.

$$scale_{it} = \frac{\partial \ln(TC_{it})}{\partial \ln(Q_{secit})} + \frac{\partial \ln(TC_{it})}{\partial \ln(Q_{dit})} \tag{5.5}$$

Scale elasticity is used as indicator of utilization of economies of scale. We analyze the effects business integration model (BIM), diversification aspects (DIV), geographical region (REG), entity type (TYPE), entity size (TA) and time trend (time) on utilization of scale economies. Business integration models include product horizontal integration (horiz), vertical integration of exchanges with CCPs (vert_exccp), vertical integration in silo model (vert_silo) and multiway integration (multi). Diversification aspects include differentiation (diff) for exchanges and CCP and ICSD formation for CSDs. Geographical regions are US region (reg_us), Europe (reg_eurp), Asia Pacific (reg_ap) and India (reg_india). Entity types are exchange (exch) and CSD. Log size of the entity is measured by log total assets (Ln TA). Market beneficial ownership type (bo) is the control variable (C). Linear time trend is also included (time). The model is presented in Equation 5.6.

$$\begin{aligned} scale_{it} = \beta_0 &+ \sum_k \beta_{1k}\, BIM_{kit} + \sum_l \beta_{2l}\, DIV_{lit} + \sum_m \beta_{3m}\, REG_{mit} \\ &+ \sum_n \beta_{4n}\, TYPE_{nit} + \beta_5 Ln(TA) + \sum_p \beta_{6p}\, C_{nit} + \beta_7 time \\ &+ u_i + e_{it} \end{aligned} \tag{5.6}$$

We employ random effects GLS regression to estimate model parameters and repeat the analysis for non-beneficial owner and beneficial owner markets. Same methods described above in short run cost methodology section (Section 5.4.2) are used, results of the diagnostic tests are presented in Appendix C.

5.4.4 Profitability

We use net profit ratio (NPR) in order to measure profitability, i.e. pricing power of the CMIs. NPR is the ratio of net income before tax (NI) to total revenues (TR) as shown in Equation 5.7.

$$NPR_{it} = \frac{NI_{it}}{TR_{it}} \tag{5.7}$$

NPR shows profitability in accounting terms. Economic profits are zero when the entities operate under perfect competition and efficient pricing (Tirole, 1998). Although we cannot measure economic profits explicitly, we assume that firms' resources are used efficiently. Consequently, accounting profits increase and decrease with an increase and decrease in economic profits monotonously. Therefore, profitability of a CMI compared to other CMIs and along with itself over years is an indicator of the CMI's comparative economic profitability. Factors that increases our accounting profitability are assumed to increase economic profitability and thus reduce economic efficiency.

We analyze the effects business integration model (BIM), business diversification effects (DIV) geographical region (REG), entity type (TYPE), entity size (TA) and time trend (time) on utilization of scale economies. Business integration models include horizontal integration (horiz), vertical integration of exchanges with CCPs (vert_exccp), vertical integration in silo model (vert_silo) and multiway integration (multi). Diversification variables are differentiation (diff), ICSD formation, diversification to data business (data) and being sole derivatives exchange (dex). Geographical regions are US region (reg_us), Europe (reg_eurp), Asia Pacific (reg_ap) and India (reg_india). Entity types are exchange (exch), and CSD. Log size of the entity is measured by log total assets (Ln TA). Market beneficial ownership type (bo) is the control variable (C). Linear time trend is also included (time). The model is presented in Equation 5.8.

$$\begin{aligned} NPR_{it} = \beta_0 &+ \sum_k \beta_{1k}\, BIM_{kit} + \sum_l \beta_{2l}\, DIV_{lit} + \sum_m \beta_{3m}\, REG_{mit} \\ &+ \sum_n \beta_{4n}\, TYPE_{nit} + \beta_5 Ln(TA) + \sum_p \beta_{6p}\, C_{nit} + \beta_7 time \\ &+ u_i + e_{it} \end{aligned} \tag{5.8}$$

We employ random effects GLS regression to estimate model parameters and repeat the analysis for non-beneficial owner and beneficial owner markets. Same methods described above in short run cost methodology section (Section 5.4.2) are used, results of the diagnostic tests are presented in Appendix D.

5.5 Empirical Findings

We first present graphical overview of total costs, total revenues and net income as well as output levels. Then we show results for the analysis of overall cost structure of the CMIs, average cost, economies of scale and profitability.

5.5.1 Descriptive results

Sum of total operating costs, total operating revenues and net income are presented in Figure 5.1.

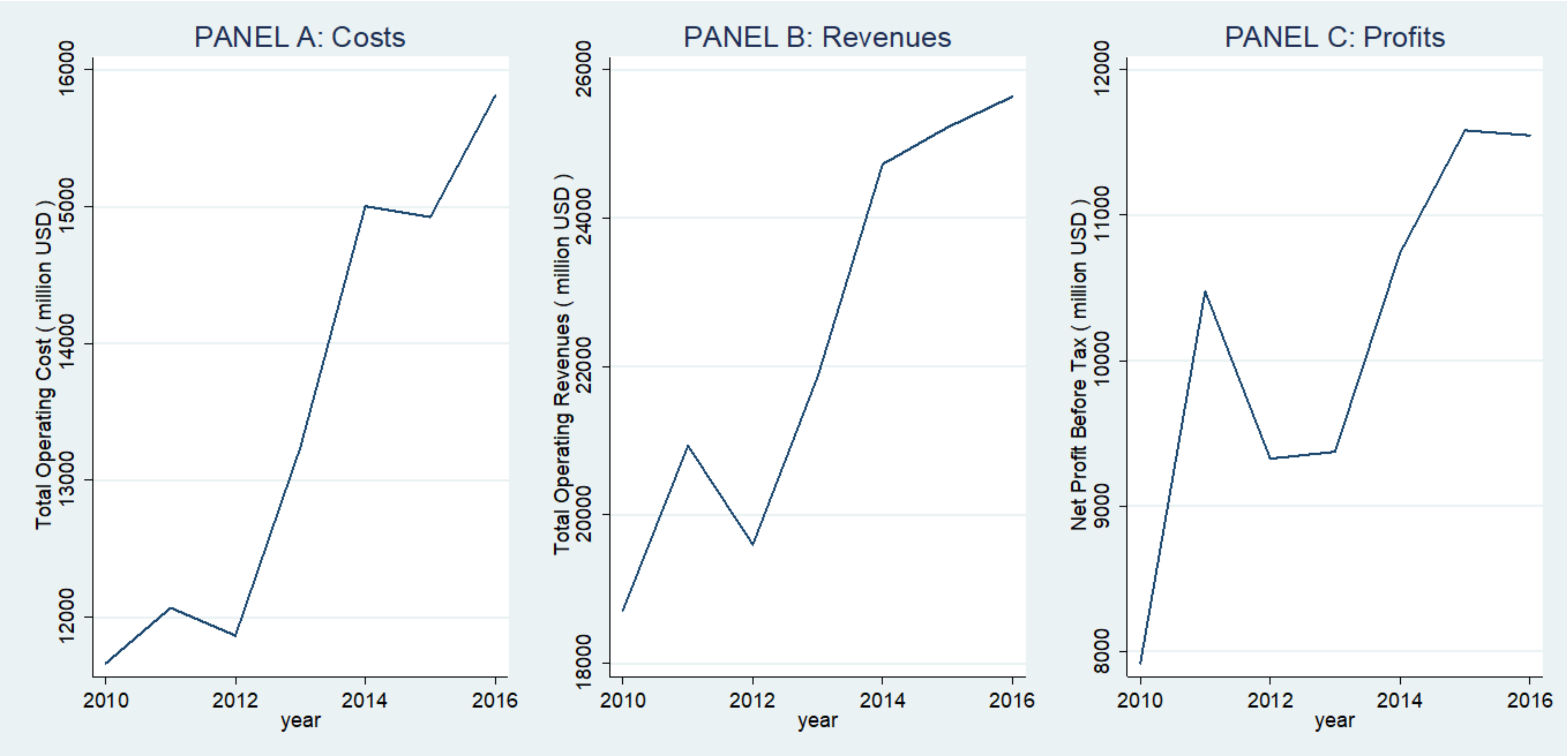


Figure 5.1 : Total annual costs, total revenues and net income before tax over time.

Figure shows that there is fluctuation between years 2010 and 2012. Total costs and revenues increase 2012 afterwards. There is discontinuity in trend in year 2012, still positive trend continues with reduced slope. Total number of securities transactions and number of derivatives contracts processed between 2010 and 2016 are presented in Figure 5.2. Number of securities transactions and derivatives contracts processed fluctuate between years 2010 and 2012. After 2012 both output levels increase. There is a minor low down in derivatives contracts processed in year 2016. As both financial and output level data is not stable between year 2010 and 2012, the data prior to 2012 are excluded from the efficiency analysis. After 2012 total costs, revenues, net income as well as number of securities transactions and derivatives contracts have a stable overall trend. In 2016 number of derivatives contracts reduces slightly. For the efficiency analysis, we try to limit effects that are not included in the model, and prefer to take a period with stable exogenous factors. In the rest of this chapter, we use data from 2012 to 2016 in our analysis.

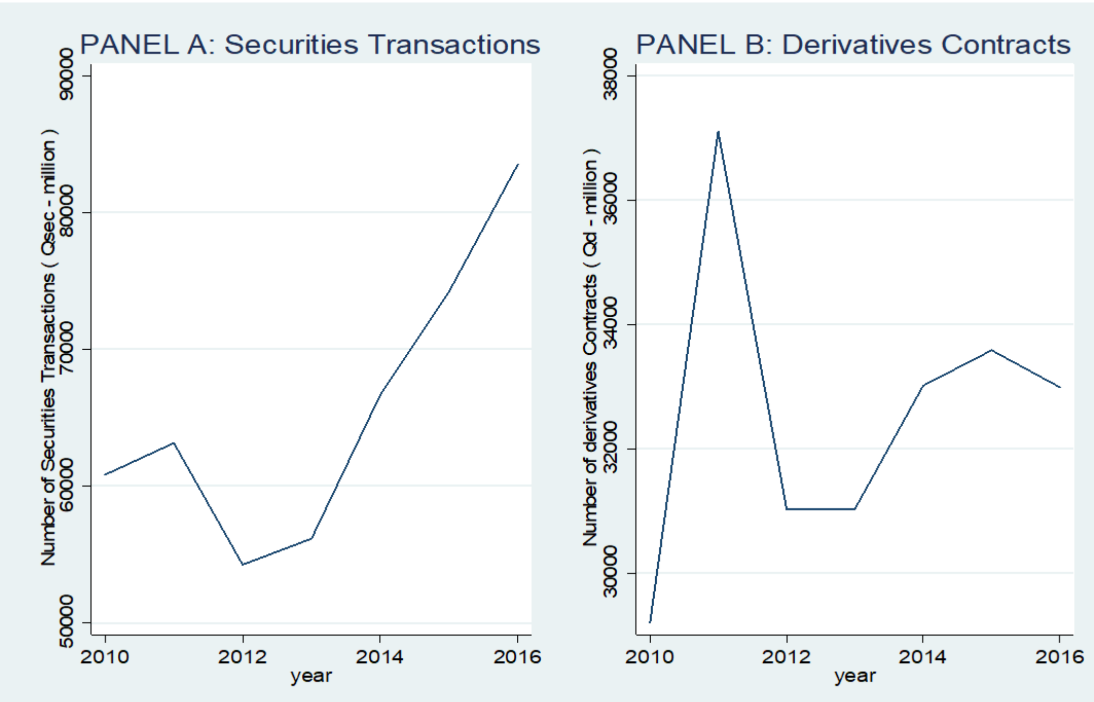


Figure 5.2 : Total number of securities transactions and number of derivatives contracts over time.

Figure 5.3 shows total costs, total revenues and net profit before tax of the CMIs as average of years 2012-2016. The US CMIs, CME Group, DTCC, Nasdaq and ICE, have largest total annual costs. European entities such as Euroclear, DBG (excluding Clearstream), LSEG and Clearstream, follow. The revenues and profits follow the same ordering of the CMIs in general. These CMIs also have high output scales in terms of number of securities transactions and derivatives contracts processed. Revenues and profits move together with the scale of outputs in general. Emerging market CMIs remain with lowest total costs as well as number of securities transactions and derivatives contracts processed. Some European CMIs also stay in the low total cost and output level area; this indicates the fragmented industry structure in European landscape.

Figure 5.4 shows number of securities transactions and derivatives contracts processed as average of years 2012-2016. The dispersion of CMIs' output volumes are in line with their total cost figures in general. DTCC has the highest securities transaction volume while CME has the highest derivatives contracts processed. Some emerging markets, i.e. KRX of Korea and NSE of India, also have high volumes. Relatively high numbers in emerging markets stems from the fact that in emerging markets all trades pass through CMIs, intermediaries do not internalize their clients' trades/transactions.

Figure 5.5 shows the univariate relationship between log total cost and log output quantities (exchanges, CCPs and CSDs are given in different colors) between 2012 and 2016. Number of exchanges is high since exchanges incorporates vertical integration with CCPs and in silo model as well as multiway integration. As the charts indicate, there is a positive univariate relation between operating costs (y-axis) and output levels (x-axis) in general. CMI type does not have any clustering effect on the cost-output structure.

DTCC has the largest costs and securities transactions processed, while CME group has largest costs and highest of derivatives contracts processed. They remain in the upper right corner of graphs in Panel A and Panel B respectively. Univariate trend is log-linear. However, in order to assess the cost structure, both securities transactions and derivatives contracts processed should be handled simultaneously.

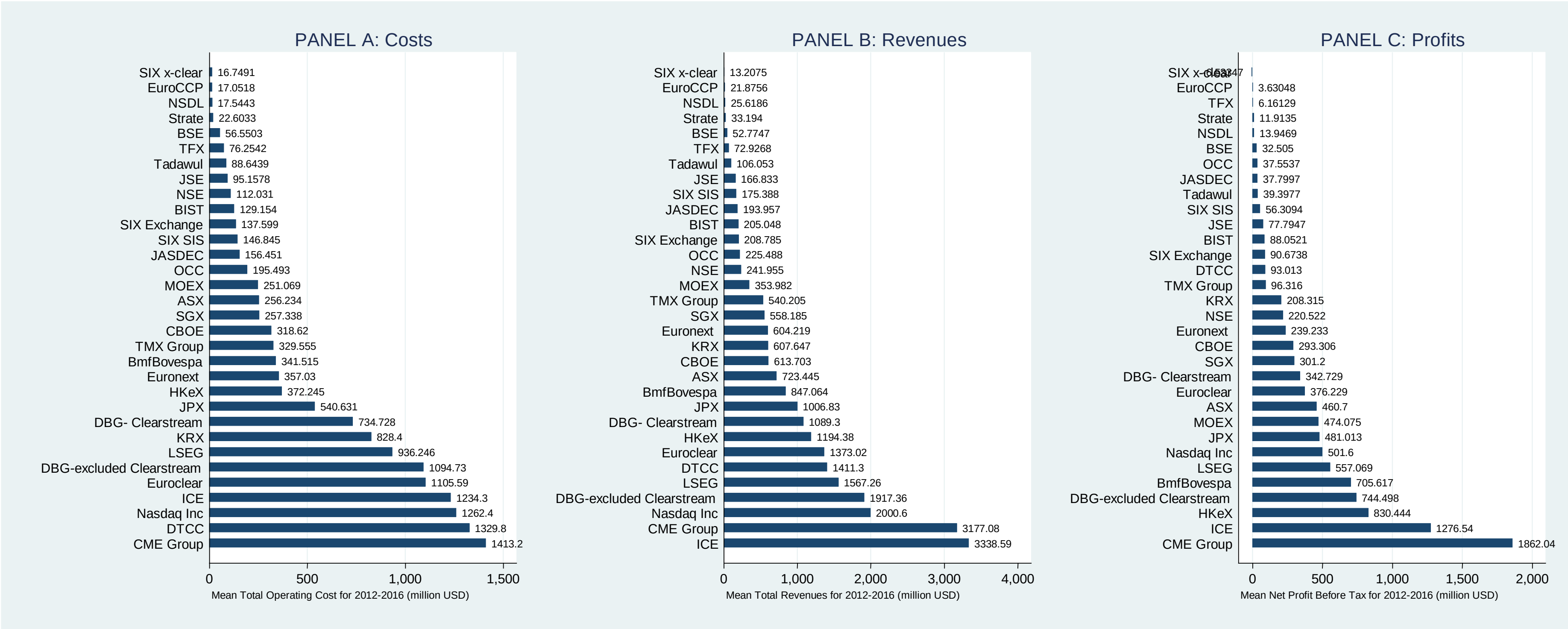
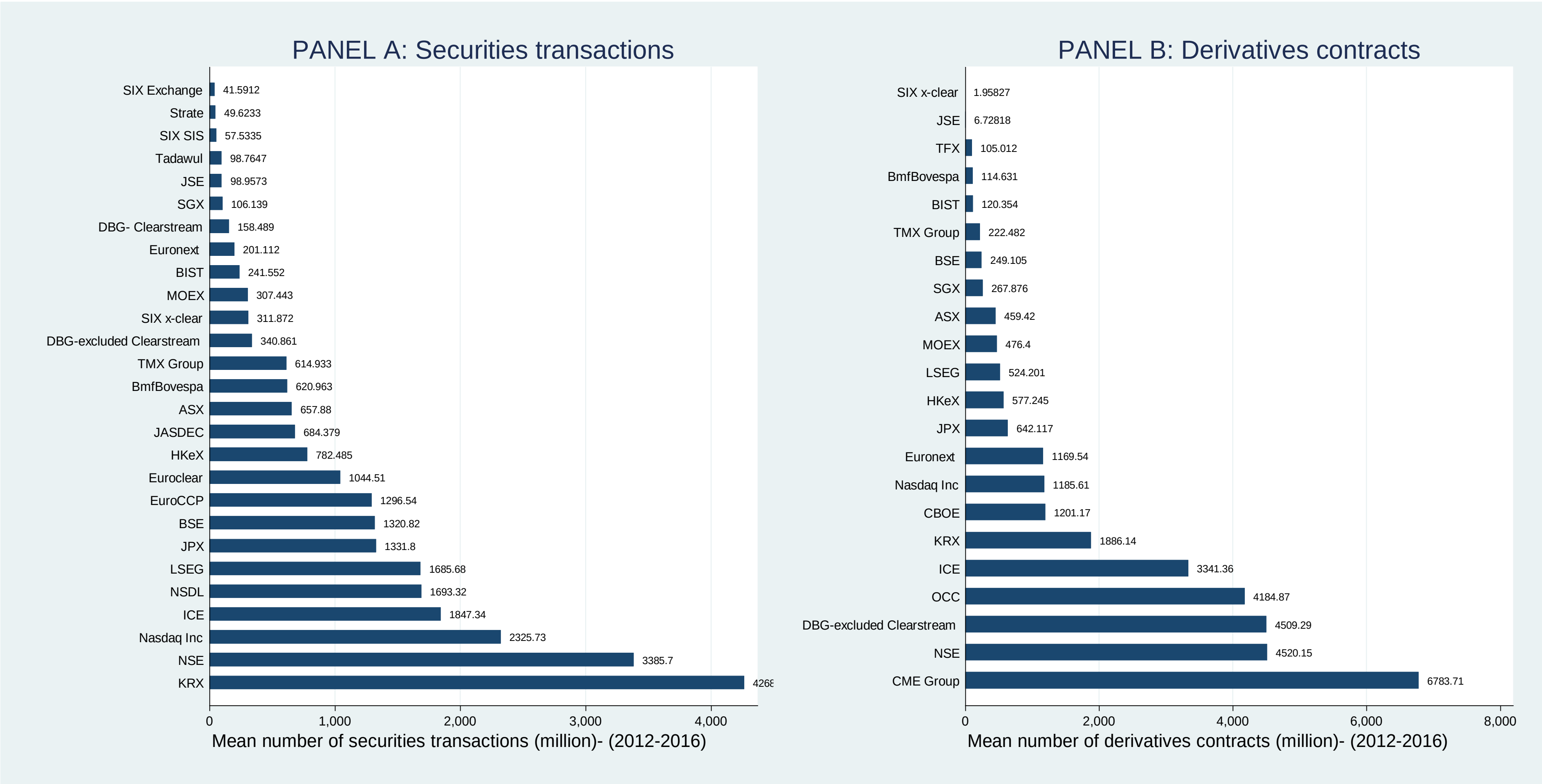
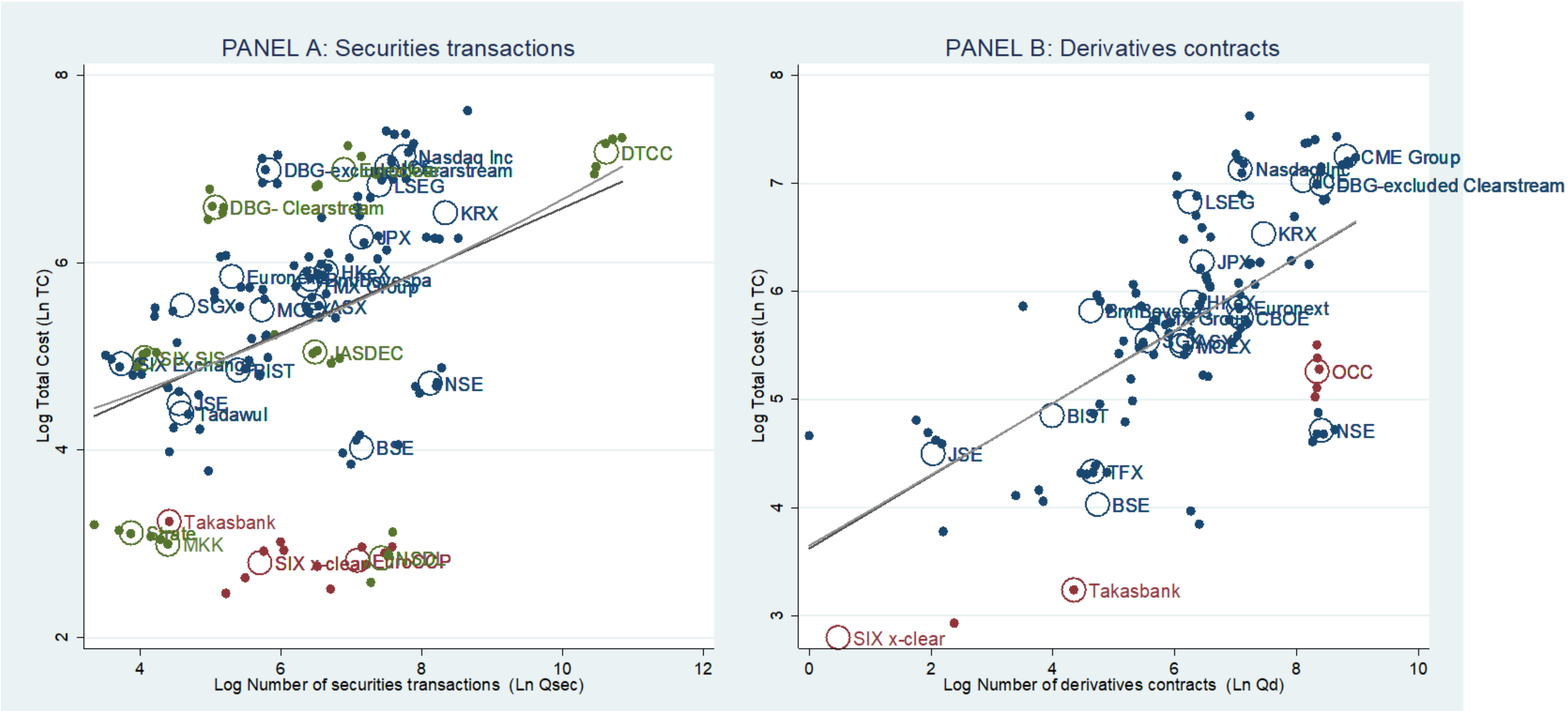


Figure 5.3 : Total costs, revenues and profits per CMI.



Note: DTCC excluded. It has 41.4 billion securities transactions (clearing and pre-settlement total).

Figure 5.4 : Number of securities transactions and derivatives contracts per CMI.



Note: Means per panel are marked with circles. Linear and quadratic trend lines fitted. Exchanges (navy), CCPs (maroon), CSDs (forest green).Years 2012-2016.

Figure 5.5 : Number of securities transactions and derivatives contracts per CMI.

5.5.2 Total cost function and technical inefficiency term

Table 5.3 gives the regression results of time-varying decay inefficiency model results for our multivariate translog cost model. Diagnostics and additional tests are provided in Appendix A. Random effects model is significant compered to fixed effects model (Table A.2) and to ordinary least squared model (OLS) (Table A.3). Serial correlation (Table A.4) and unit root stationary tests (Table A.5) are also conducted.

Log total cost has significant positive relationship with squared log quantity terms at 95 % confidence level. Coefficients are 0.0616 for squared log securities transactions ($(\text{Ln } (Q_{sec})^2$) and 0.0606 for squared log derivatives contracts ($(\text{Ln } (Q_d)^2$). The coefficient of log securities transactions ($(\text{Ln } (Q_{sec})$) is -1.4130, the confidence level is low though (p-value=0.081). The coefficient of log derivatives contracts ($(\text{Ln } (Q_d)$) is -1.7617, the coefficient of interaction of log derivatives output and log price level is 0.1203.Both coefficients are significant. The net effect of economies of scale cannot be directly seen from coefficients of quantity terms in the total cost model. The level of the economies of scale utilized is measured by the scale elasticity which are derived from output elasticity of total cost. Coefficients which are significant at 95% confidence level are considered. The estimation results are presented in section 5.5.4. Log price level is significant and positive in log quadratic terms, significant and negative in log terms. Interaction term of the two output terms as well as interaction of log securities output and price level is insignificant.

Market beneficial ownership has positive but insignificant effect on total cost. Among institution types, exchange and ICSD is have positive and significant effect on total cost while effect of CSD is insignificant. Exchanges' median total costs are three times, ICSDs' median total costs are seven times larger than other CMIs[6].

Business integration models are jointly significant (Table A.6). Among integration models, total cost increases with vertical integration in silo model, the significance level is % 93 though. Effects of other integrations are insignificant. Coefficient of vert_silo is significantly different from the coefficients of other integration models (Table A.7). We also include the business integration models in the model individually to see their effect compared to the rest of all integration categories. Horizontal

[6] If binary variable in log linear regressions changes from zero to 1, dependent variable increases by exp(coefficient)-1.

integration and vertical integration of exchanges and CCPs are insignificant. Silo model vertically integrated CMIs have significantly higher, multiway integrated CMIs have significantly lower total cost (Table A.8). Diversification aspects are also jointly significant. ICSDs are significantly more costly than other CMIs.

Table 5.3 : Panel data frontier regression results for log total cost (Ln TC).

Ln TC	**Coef.**	**Std.Err.**	**z**	**P>z**	**[95% Conf. Int.]**	
$(\text{Ln Qsec})^2$	0.0616	0.0133	4.6500	0.0000	0.0356	0.0876
$(\text{Ln Qd})^2$	0.0606	0.0177	3.4200	0.0010	0.0258	0.0954
Ln Qsec	-1.4130	0.8103	-1.7400	0.0810	-3.0012	0.1752
Ln Qd	-1.7617	0.3505	-5.0300	0.0000	-2.4486	-1.0748
Ln Qsec*Ln Qd	0.0069	0.0138	0.5000	0.6170	-0.0202	0.0340
$(\text{Ln P})^2$	0.3087	0.1515	2.0400	0.0420	0.0118	0.6057
Ln P	-6.7954	3.1236	-2.1800	0.0300	-12.9175	-0.6733
Ln P* Ln Qsec	0.0879	0.0757	1.1600	0.2450	-0.0604	0.2362
Ln P*Ln Qd	0.1203	0.0306	3.9300	0.0000	0.0603	0.1803
Ln GDP	0.6097	0.1157	5.2700	0.0000	0.3830	0.8364
time	0.0405	0.0259	1.5600	0.1180	-0.0103	0.0912
bo	0.3071	0.2361	1.3000	0.1930	-0.1556	0.7699
exch	1.3878	0.2977	4.6600	0.0000	0.8042	1.9713
CSD	0.4456	0.3111	1.4300	0.1520	-0.1641	1.0552
ICSD	2.0842	0.3507	5.9400	0.0000	1.3967	2.7716
diff	0.8295	0.5245	1.5800	0.1140	-0.1986	1.8575
horiz	-0.0989	0.2845	-0.3500	0.7280	-0.6565	0.4587
vert_exccp	-0.0176	0.2681	-0.0700	0.9480	-0.5430	0.5078
vert_silo	0.4349	0.2510	1.7300	0.0830	-0.0570	0.9269
multi	-0.3546	0.2716	-1.3100	0.1920	-0.8869	0.1777
reg_us	-0.1197	0.4028	-0.3000	0.7660	-0.9091	0.6698
reg_eurp	0.4394	0.2959	1.4800	0.1380	-0.1406	1.0193
reg_ap	0.1311	0.2449	0.5400	0.5920	-0.3489	0.6111
reg_india	-2.0467	0.5956	-3.4400	0.0010	-3.2141	-0.8793
constant	23.1318	15.7692	1.4700	0.1420	-7.7752	54.0387
/mu	0.4308	0.2477	1.7400	0.0820	-0.0547	0.9164
/eta	0.1209	0.0244	4.9500	0.0000	0.0730	0.1687
/lnsigma2	-1.3290	0.5416	-2.4500	0.0140	-2.3904	-0.2675
/ilgtgamma	1.8801	0.6868	2.7400	0.0060	0.5339	3.2263
sigma2	0.2647	0.1434			0.0916	0.7653
gamma	0.8676	0.0789			0.6304	0.9618
sigma_v2	0.2297	0.1448			-0.0541	0.5135
sigma_e2	0.0350	0.0051			0.0251	0.0450

Time-varying decay inefficiency model. Number of observations= 161, Number of groups= 34.Log likelihood = -15.419147, Wald $\chi2$ (24)= 1330.58, Prob $\chi2$ >0 =0.000. Ln: natural logarithm, TC: total cost. Quantities Qsec: number of securities transactions, Qd: number of derivatives contracts, P: price level, bo: market beneficial ownership type, time: linear time trend, exch: exchange, diff: asset class differentiation, horiz: horizontal integration, vert_exccp: vertical integration of exchanges with ccps, vert_silo: vertical integration of whole trade and post-trade value chain, multi: multiway integration, reg_us: USA, reg_eurp: Europe, reg_ap: Asia Pacific, reg_india: India. Mu: mean inefficiency component, eta: time decay parameter, sigma2_v2: total variance of entity specific inefficiency term's variance, sigma_e2: idiosyncratic error term's variance, sigma2: total of sigma_v2 and sigma_e2, gamma: sigma2_v2/ sigma2 (it is between 0 and 1). Optimization is parameterized in terms of inverse logit of gamma (ilgtgamma) and log sigma2 (lnsigma2).

Region variables are jointly significant as well. Log likelihood ratio tests are provided in Table A.6. Among regions total costs are lower in India significantly. We also compare the equality of coefficients of region variables, coefficient of reg_india is significantly different (Table A.7). US, Europe and Asia Pacific regions are insignificant compared to the CMIs which belong to neither of these three regions. However, when US, Europe and Asia Pacific are individually included in the model and compared to the rest of all CMIs other than India, CMIs in the US are significantly less costly, CMIs in the Europe is significantly more costly. Region Asia Pacific is insignificant (Table A.9).

Technical inefficiency term (mu) is significant only at 91 % significance level, therefore we assume the significance of technical inefficiency is low. However, time decay parameter (eta) is positive and strongly significant (p-value<0.00). This indicates that possible technical inefficiency components are reducing over time.

5.5.3 Short-run costs

Average transaction costs indicate short run costs. To maintain a simple estimation we drive an expansion path between number of securities transactions and derivatives contracts. Then we re-write number of derivatives contracts in terms of equivalent number securities transactions. Then we simply calculate average cost as total costs divided by number of securities equivalent transactions. Therefore, the average cost estimation indicates comparative position of the CMIs' unit cost structure.

5.5.3.1 Expansion path

The data is stratified in three groups. First group includes vast majority of the markets. The markets in this group are Australia, Brazil, Canada, Hong Kong, Japan, Russia, Singapore, South Africa and Turkey. Korea and India are separated from this group due to higher output levels. Europe and the US are regarded as third group as they are two leading marketplaces that sets the trends. Figure 5.6 provides general relation between number of securities transactions and derivatives contracts processed per market. The expansion path estimation is provided in Table 5.4. Q_{sec} is equal to 1.195 times Q_d in markets where $Q_d \leq 1000$. Q_{sec} is equal to 1.316 times Q_d in markets in India and Korea. Qsec is equal to 2.228 times Q_d in the USA and Europe.

The models enable us to obtain number of securities transaction equivalent for one derivative contract processed in the relevant market. No constant models are used in order to get consistent estimators when the expansion paths are applied to entity level data. Average cost is calculated as total costs divided by number of securities equivalent transactions.

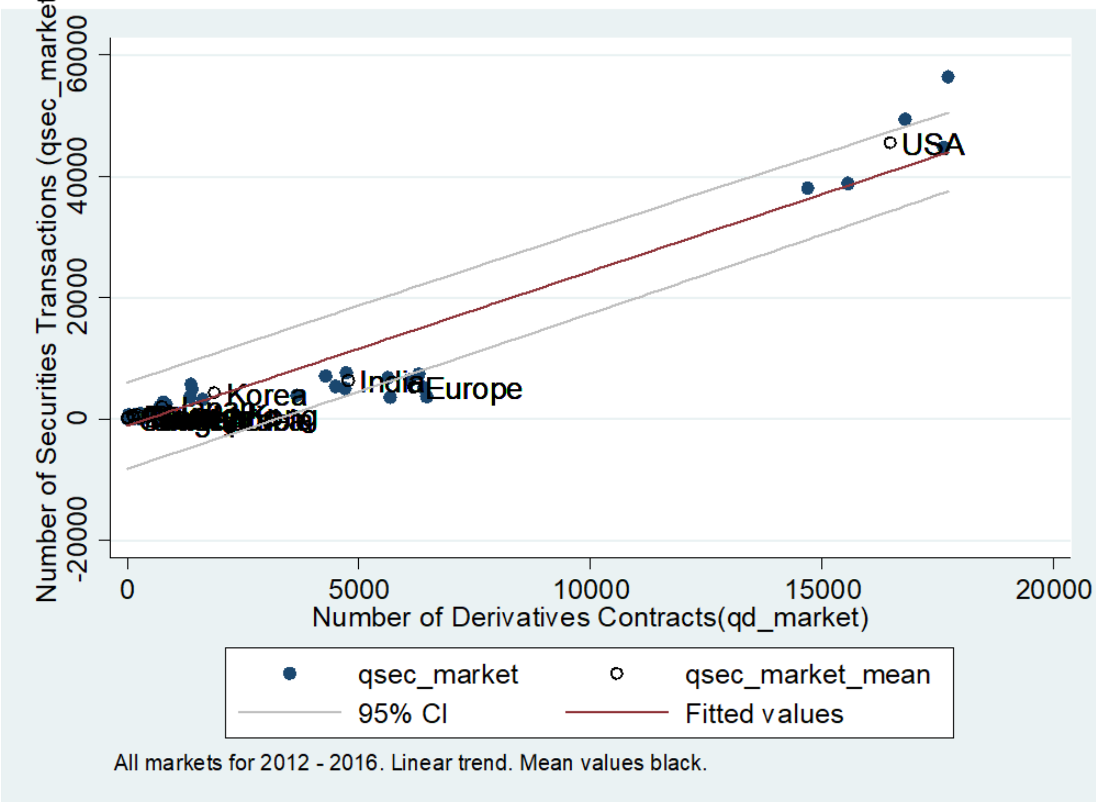
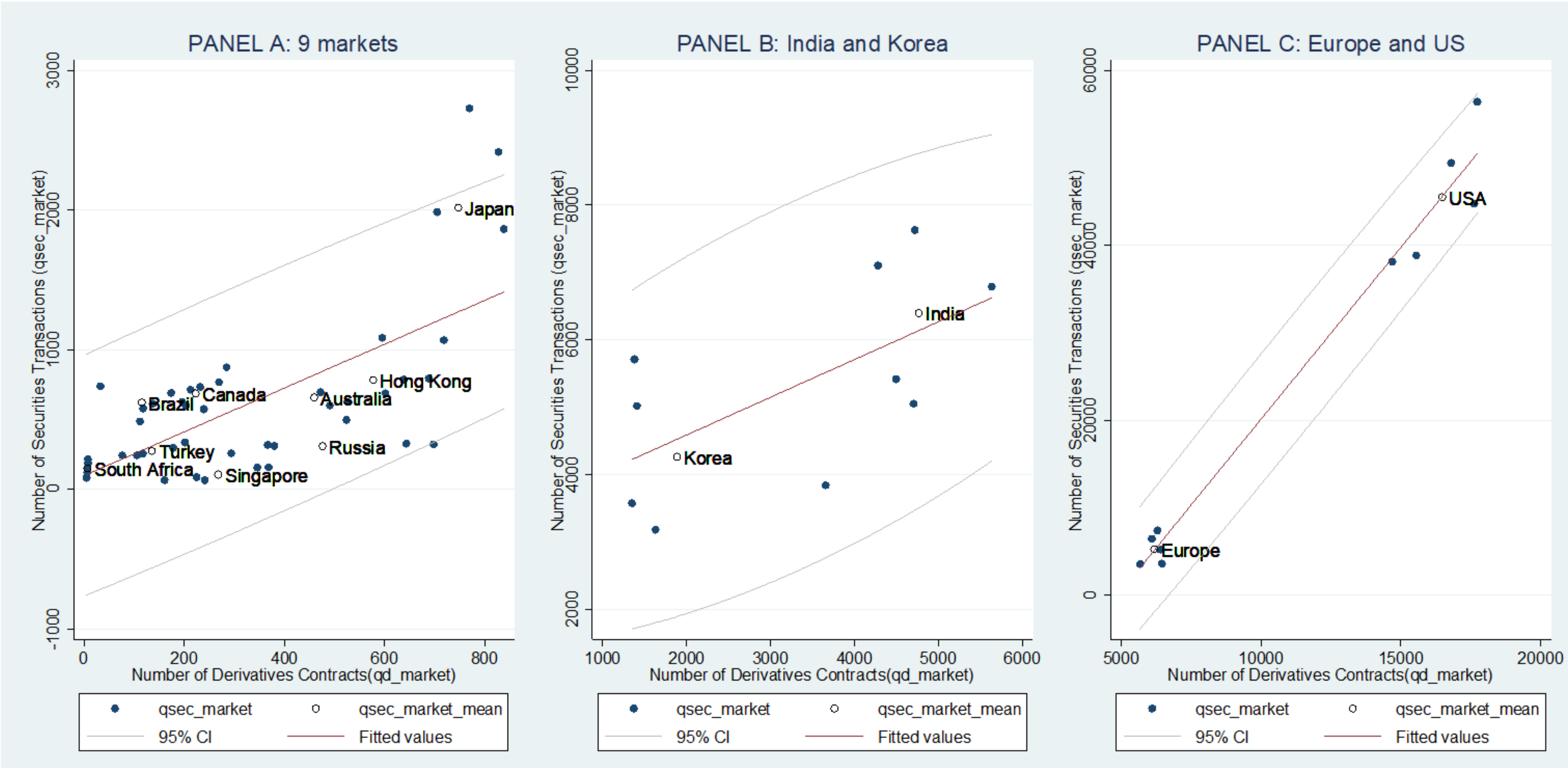


Figure 5.6 : Number of securities transactions and number of derivatives contracts

Table 5.4 : Expansion path between number of securities transactions (Q_{sec}) and derivatives contracts (Q_d) processed.

Group	Q_{sec}	Coef.	St.Err.	Z	P>z	[95% Conf. Int.]	
$Q_d \leq 1000$	Qd	1.1953	0.1371	8.72	0.000	0.9266	1.4639
India and Korea	Qd	1.3164	0.7396	17.80	0.000	1.1714	1.4613
USA and Europe	Qd	2.2890	0.1503	15.23	0.000	1.9944	2.5837

Cross-sectional time-series FGLS regression. Generalized Least Square coefficients with heteroskedastic panels and panel-specific AR (1) correlation. For $Q_d \leq 1000$ (Australia, Brazil, Canada, Hong Kong, Japan, Russia, Singapore, South Africa, Turkey); estimated covariances=9, estimated autocorrelations=9, estimated coefficients=1, number of observations=45, number of groups=2, Wald chi2(1) =76.04, prob > chi2=0.0000. For Group India and Korea; estimated covariances=2, estimated autocorrelations=2, estimated coefficients=1, number of observations=10, number of groups=2, Wald chi2(1) =316.77, prob > chi2=0.0000. For group USA and Europe estimated covariances=2, estimated autocorrelations=2, estimated coefficients=1, number of observations=10, number of groups=2, Wald chi2(1) =231.82, prob > chi2=0.0000.

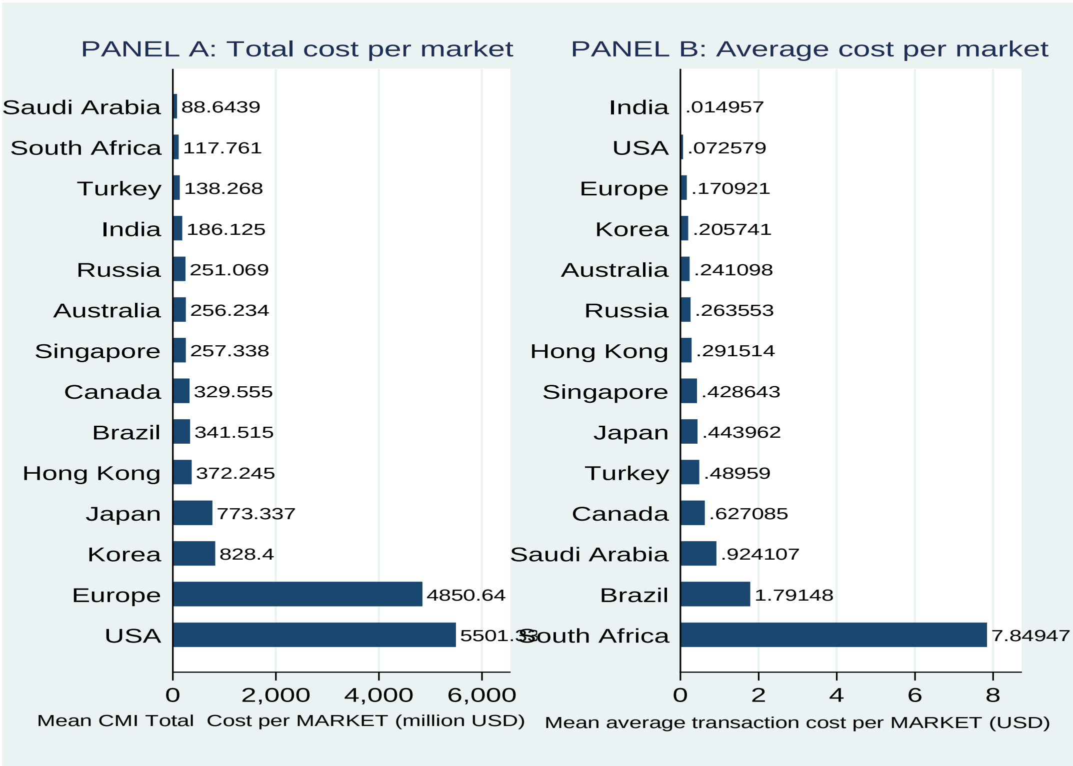


Note: Mean values are marked with small black circles, linear trend fitted. Years 2012-2016. 9 markets are Australia, Brazil, Canada, Hong Kong, Japan, Russia, Singapore, South Africa and Turkey.

Figure 5.7 : Number of securities transactions and number of derivatives contracts

5.5.3.2 Market level results

Figure 5.7 shows total cost (Panel A) and the average transaction cost estimates (Panel B) per market. India is a special case where total costs are moderate and average costs is the lowest. For other markets as the total costs are reduced, average costs increase. USA and Europe have the highest total cost and lowest average costs after India. These results reveal that these two markets have scale economies. This also indicates fixed costs are high in the CMI industry, therefore smaller markets cannot benefit from economies of scale as much as the bigger ones. Average costs are higher in smaller markets. There is clear descriptive evidence for the economies of scale.



Note: Years 2012-2016.

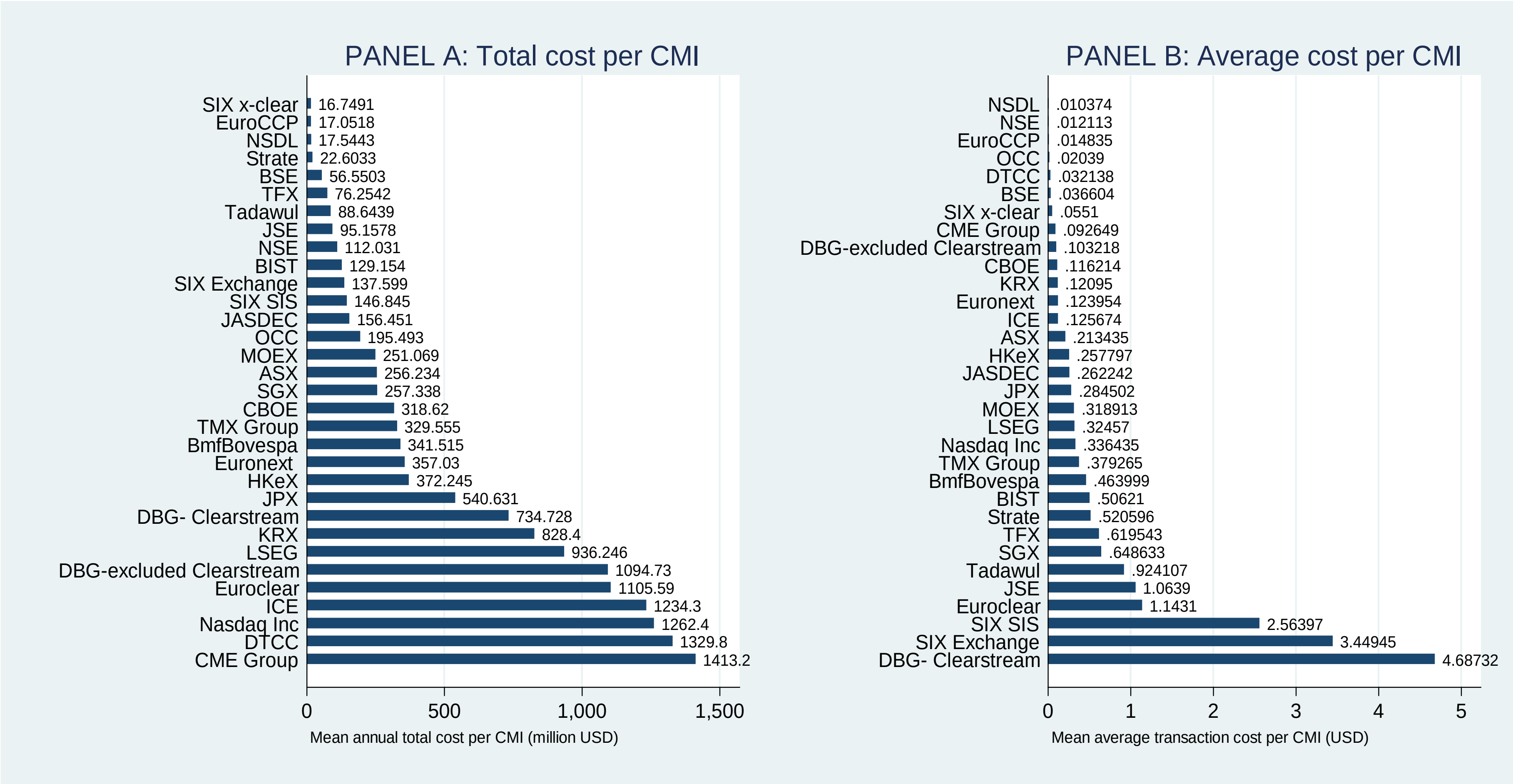
Figure 5.8 : Total cost and average cost per market.

5.5.3.3 CMI level results

Figure 5.8 shows total cost (Panel A) and the average transaction cost estimates (Panel B) per CMI. CME Group, DTCC, ICE and Nasdaq rank with highest total costs, their average costs are low as well. SIX Exchange is the outlier with low output level in Europe. ICSDs have high average costs, as expected due to the complexity of their business. In addition, ICSDs serve for a wholesale market where pre-settlement (not netted) volumes are almost equal to settlement volumes.

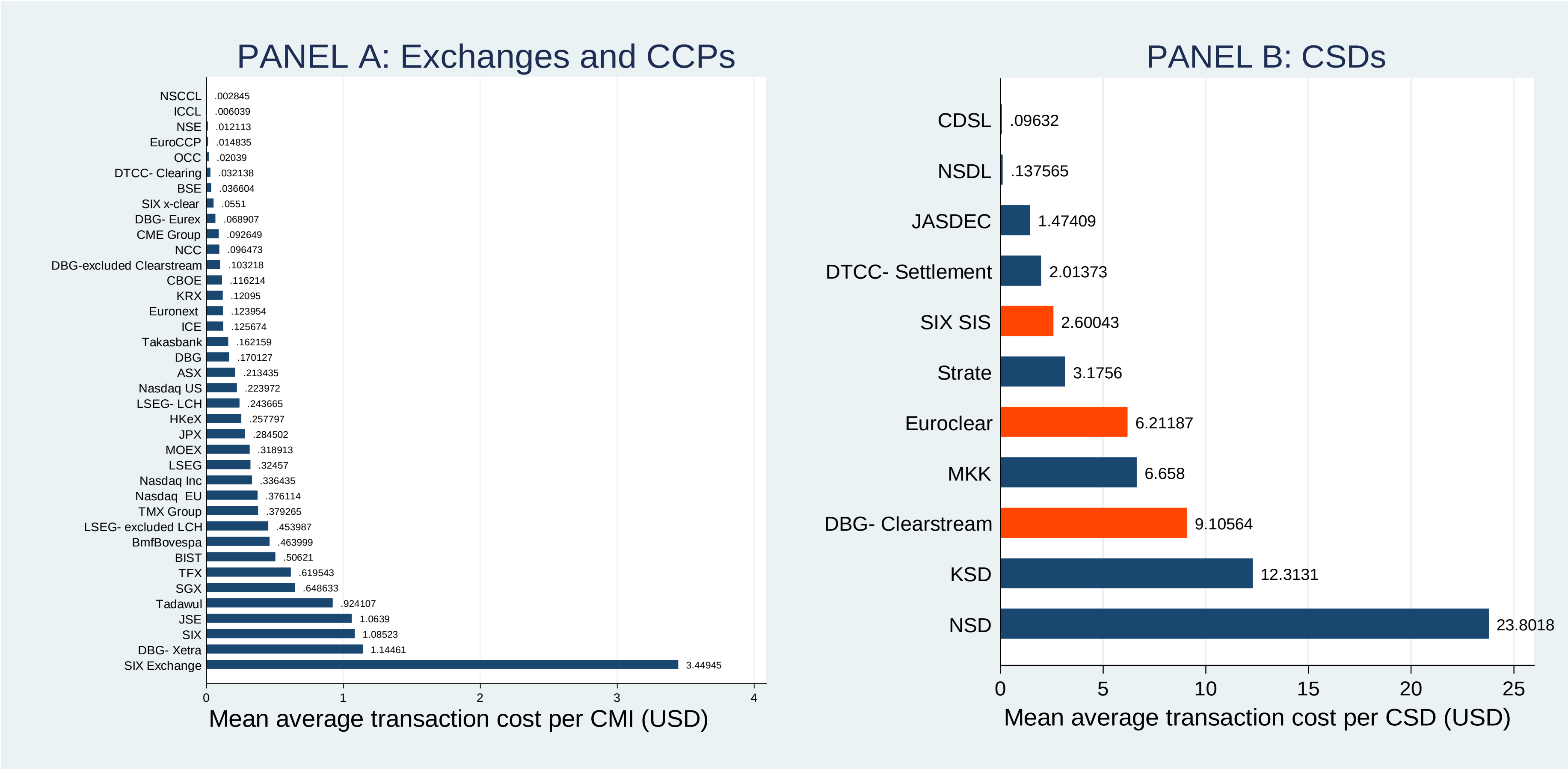
In order to be able to compare the exchanges and CSDs separately, we present Figure 5.9. In Panel A average cost for exchanges and CCPs are presented. Subsidiaries under one group entity are also shown where possible. In Panel B of Figure 5.9 we present the average cost per netted settlement transactions of CSDs including the ICSDs. We can see that the two ICSDs, Euroclear and DB Clearstream, which provide cross border settlement services in multiple markets globally, have higher per transaction cost compared to other non-beneficial owner market CSDs. We should note that the other ICSD, SIX SIS, has local client base, while Euroclear and Clearstream have global client bases. Furthermore, Euroclear and Clearstream are the CSDs of international bonds and have additional functions. NSD of Russia and KSD of Korea have the highest average costs. The two Indian CSDs (NSDL and CSDL) have lowest cost. DTCC and Jasdec are the lowest cost CSDs that operate in developed markets.

Tables 5.5 to 5.9 show the results of regressions for average cost against integration, region, entity type, company size and time effects. Among integration variables independent (indep) indicates non-integrated CMIs. CBOE is the only non-integrated exchange in our dataset. MKK is non-integrated only for year 2012. Euronext is the only horizontally integrated exchange in the dataset. Seven post-trade institutions are horizontally integrated (Jasdec, EuroCCP, Euroclear, NSDL, Strate, OCC, Takasbank). TFX of Japan, NSE of India and JSE of South Africa are the exchanges with CCP integration. There are eight multiway and 13 silo model vertically integrated CMIs in the dataset. As the five integration models; namely independence (no integration), horizontal, vertical exchange CCP, vertical silo and multiway integration, are mutually exclusive, all cannot be presented in the same regression due to computational issues, otherwise collinearity occurs. Therefore, the integration models, which have low number of observations and insignificant are omitted. As integration categories and region variables are categorical variables they are tested for significant difference with the other categories. Additionally each category is included in the model individually to compare the effect of the category with the rest of the categories. Panel regression diagnostics are provided in the Appendix B.



Note: Years 2012-2016.

Figure 5.9 : Total and average cost per CMI



Note: Years 2012-2016. Panel A: pre- settlement , Panel B: post-settlement figures. ICSDs (Panel B) are marked with different color.

Figure 5.10 : Average cost per CMI (pre and post settlement figures).

In Table 5.5 overall results are shown. Integration does not have significant effect on average cost. No integration model has significant effect on the average cost. US and Asia Pacific regions have significantly lower average costs compared to the regions other than US, Asia Pacific, Europe and India. Coefficients are -0.7918 and -0.4503 respectively. None of the region categories are significantly different from the other region categories (Table B.6). US region have significantly lower cost compared to all other regions (Table B.7). Average costs are reduced significantly over time significantly with coefficient -0.0665. Size increases average cost; insignificance level is low though. Its coefficient is 0.0649 with p-value= 0.057. Entity type, differentiation, ICSD, market beneficial ownership type are insignificant.

Table 5.5 : Random effects GLS regressions for average cost.

AC	Coef.	Std.Err.	z	P>z	[95% Conf. Int.]	
diff	-0.3638	0.3494	-1.0400	0.2980	-1.0486	0.3210
indep	0.4516	0.3251	1.3900	0.1650	-0.1855	1.0887
horiz	-0.4700	0.4150	-1.1300	0.2570	-1.2834	0.3435
vert_silo	0.0865	0.1741	0.5000	0.6190	-0.2548	0.4278
multi	-0.2130	0.1608	-1.3200	0.1850	-0.5281	0.1022
Ln TA	0.0649	0.0341	1.9000	0.0570	-0.0020	0.1317
time	-0.0665	0.0287	-2.3100	0.0210	-0.1228	-0.0102
reg_us	-0.7918	0.3130	-2.5300	0.0110	-1.4053	-0.1782
reg_eurp	0.0947	0.5317	0.1800	0.8590	-0.9475	1.1369
reg_ap	-0.4503	0.2063	-2.1800	0.0290	-0.8547	-0.0460
reg_india	-0.1963	0.1880	-1.0400	0.2970	-0.5648	0.1722
bo	-0.3399	0.2244	-1.5100	0.1300	-0.7798	0.1000
exch	0.3290	0.5109	0.6400	0.5200	-0.6722	1.3303
CSD	0.2800	0.5046	0.5500	0.5790	-0.7090	1.2690
ICSD	1.7577	1.0886	1.6100	0.1060	-0.3759	3.8913
_cons	0.3434	0.6795	0.5100	0.6130	-0.9884	1.6753
sigma_u	0.7152					
sigma_e	0.2725					
rho	0.8733					

Random Effects GLS Regression. Group variable: entity, number of obs = 161, number of groups = 34, within R-sq = 0.1791, between R-sq= 0.5741, overall R-sq = 0.5623 Wald chi2(15) = 59.06 corr(u_i, X) = 0 (assumed), prob > chi2= 0.0000, standard errors adjusted for 34 clusters in entities. AC: average cost, diff: product differentiation, indep: independent, horiz: horizontal integration, vert_silo: vertical integration of whole value chain, multi: multiway integration, Ln TA: log total assets (size), time: linear time trend, reg_us: US, reg_eurp: Europe, reg_india: India, reg_ap: Asia Pacific. sigma_u: standard deviation of panel entity-specific time-invariant error term, sigma_e: standard deviation of the idiosyncratic error component, rho: fraction of variance due to u_i.

Diagnostic tests are presented in Appendix B. Cross sectional dependence and serial correlations could not be rejected. Still these are not big issues for micro panels less than 20 years (Baltagi, 2013). In addition we use the models to interpret the availability and direction of effects of independent variables on the dependent variable, we do not make forecasts. Therefore, we are contented with the robustness of our results.

Table 5.6 shows the integration, region, size and time effects on average cost for exchanges specifically. Differentiation reduces costs significantly, its coefficient is -0.9781. Horizontal integration have significant cost reduction effects compared to vertical integration both in the form of exchange and CPP integration and silo. Test for significance for the coefficients of integration variables (Table B.8) and model where all vertical integration is regarded as comparison group (Table B.9) is provided in Appendix B.

Table 5.6 : Random effects GLS regressions for average cost of exchanges.

AC	Coef.	Std.Err.	z	P>z	[95% Conf. Int.]	
diff	-0.9781	0.3904	-2.5100	0.0120	-1.7432	-0.2129
indep	-0.0704	0.3625	-0.1900	0.8460	-0.7809	0.6400
horiz	-0.9281	0.4296	-2.1600	0.0310	-1.7701	-0.0861
vert_silo	0.2251	0.2159	1.0400	0.2970	-0.1981	0.6483
multi	-0.2893	0.1872	-1.5500	0.1220	-0.6563	0.0776
Ln TA	0.0014	0.0250	0.0600	0.9550	-0.0475	0.0503
time	-0.0547	0.0381	-1.4400	0.1500	-0.1293	0.0199
reg_us	-0.8887	0.4302	-2.0700	0.0390	-1.7320	-0.0455
reg_eurp	0.5183	0.5100	1.0200	0.3090	-0.4812	1.5178
reg_ap	-0.4700	0.2395	-1.9600	0.0500	-0.9393	-0.0007
reg_india	-0.2514	0.1906	-1.3200	0.1870	-0.6248	0.1221
bo	-0.3983	0.2732	-1.4600	0.1450	-0.9339	0.1373
_cons	1.6390	0.3668	4.4700	0.0000	0.9201	2.3579
sigma_u	0.4368					
sigma_e	0.2693					
rho	0.7246					

Random Effects GLS Regression. Group variable: entity, number of obs = 109, number of groups = 22, within R-sq = 0.1894, between R-sq= 0.6304, overall R-sq = 0.5758 Wald chi2(12) = 157.12 corr(u_i, X) = 0 (assumed), prob > chi2= 0.0000, standard errors adjusted for 22 clusters in entities. AC: average cost, diff: product differentiation, indep: independent, horiz: horizontal integration, vert_silo: vertical integration of whole value chain, multi: multiway integration, Ln TA: log total assets (size), time: linear time trend, reg_us: US, reg_eurp: Europe, reg_ap: Asia Pacific, reg_india: India. sigma_u: standard deviation of panel entity-specific time-invariant error term, sigma_e: standard deviation of the idiosyncratic error component, rho: fraction of variance due to u_i.

Time and size are insignificant. Among regions, US and Asia Pacific have significantly lower costs with coefficients -0.8887 and -0.4700 respectively. However, additional tests for significance of coefficients reveal that there is no significant difference between US and the Asia Pacific regions; still both regions have significantly lower cost compared to Europe (Table B.8). US exchanges have the lower and Europe have higher average costs compared to the rest of the dataset (Table B.10). Euronext, the only horizontally integrated exchange, have significantly lower costs than vertically integrated exchanges.

Table 5.7 shows the integration, region, size and time effects on average cost in non-beneficial owner (developed) markets specifically. Differentiation, integration, horizontal and vertical integrations as well as region and entity type are insignificant. Multiway integration reduces average cost with coefficient -0.3263 compared to independent and vertical integration of exchanges with CCPs. However, none of the integration categories in the model have significantly different coefficient (Table B.11). Time has a negative significant effect on average costs (coefficient= -0.0891). Size increases the average cost with coefficient 0.0929.

Table 5.7 : Random effects GLS regressions for average cost in non-beneficial owner markets.

AC	Coef.	Std.Err.	z	P>z	[95% Conf. Int.]	
diff	-0.1308	0.2801	-0.4700	0.6400	-0.6798	0.4181
indep	0.0249	0.3215	0.0800	0.9380	-0.6053	0.6550
horiz	-0.6345	0.4630	-1.3700	0.1710	-1.5420	0.2730
vert_silo	0.2256	0.1940	1.1600	0.2450	-0.1547	0.6059
multi	-0.3263	0.1903	-1.7100	0.0860	-0.6994	0.0467
Ln TA	0.0929	0.0555	1.6700	0.0940	-0.0159	0.2017
time	-0.0891	0.0386	-2.3100	0.0210	-0.1647	-0.0136
reg_us	-0.5734	0.4310	-1.3300	0.1830	-1.4181	0.2714
reg_eurp	0.2205	0.6408	0.3400	0.7310	-1.0355	1.4765
reg_ap	-0.5198	0.3486	-1.4900	0.1360	-1.2032	0.1635
exch	0.3560	0.6630	0.5400	0.5910	-0.9436	1.6555
CSD	0.7820	0.7067	1.1100	0.2690	-0.6032	2.1672
ICSD	1.3522	1.1800	1.1500	0.2520	-0.9605	3.6649
_cons	-0.0702	0.8483	-0.0800	0.9340	-1.7328	1.5924
sigma_u	0.9574					
sigma_e	0.2873					
rho	0.9174					

Random Effects GLS Regression. Group variable: entity, number of obs = 114, number of groups = 23, within R-sq = 0.1927, between R-sq= 0.5464, overall R-sq = 0.5266 Wald chi2(13) = 61.44 corr(u_i, X) = 0 (assumed), prob > chi2= 0.0000, standard errors adjusted for 23 clusters in entities. AC: average cost, diff: product differentiation, indep: independent, horiz: horizontal integration, vert_silo: vertical integration of whole value chain, multi: multiway integration, Ln TA: log total assets (size), time: linear time trend, reg_us: US, reg_eurp: Europe, reg_ap: Asia Pacific. sigma_u: standard deviation of panel entity-specific time-invariant error term, sigma_e: standard deviation of the idiosyncratic error component, rho: fraction of variance due to u_i.

Table 5.8 shows the effects on the exchanges in non-beneficial owner (developed) markets. Differentiation reduces average cost with coefficient -1.1069 (p-value=0.081). Horizontal integration reduces the average costs significantly with coefficient 0.669 compared to the non-integration (indep) and exchange CCP vertical integration. Coefficients of horizontal and multiway integrations are significant compared to silo model vertical integration, but there is no difference between the coefficients of horizontal and multiway integration (Table B.12, Table B.13). Region variables as well as entity size and time are insignificant.

Table 5.8 : Random effects GLS regressions for average cost for exchanges in non-beneficial owner markets.

AC	Coef.	Std.Err.	z	P>z	[95% Conf. Int.]	
diff	-1.1069	0.6350	-1.7400	0.0810	-2.3514	0.1377
horiz	-0.6696	0.3804	-1.7600	0.0780	-1.4151	0.0759
vert_silo	0.3804	0.2812	1.3500	0.1760	-0.1708	0.9316
multi	-0.2489	0.1638	-1.5200	0.1290	-0.5700	0.0722
Ln TA	0.0366	0.0543	0.6700	0.5000	-0.0699	0.1431
time	-0.0848	0.0617	-1.3700	0.1690	-0.2056	0.0361
reg_us	-1.0787	0.6852	-1.5700	0.1150	-2.4216	0.2642
reg_eurp	0.3073	0.5235	0.5900	0.5570	-0.7187	1.3332
reg_ap	-0.6946	0.4863	-1.4300	0.1530	-1.6479	0.2586
_cons	1.5525	0.4996	3.1100	0.0020	0.5734	2.5316
sigma_u	0.0000					
sigma_e	0.2548					
rho	0.0000					

Random Effects GLS Regression. Group variable: entity, number of obs = 69, number of groups =14, within R-sq = 0.1743, between R-sq= 0.6108, overall R-sq = 0.5684 Wald chi2(9) = 81.00 corr(u_i, X) = 0 (assumed), prob > chi2= 0.0000, standard errors adjusted for 14 clusters in entities. AC: average cost, diff: product differentiation, horiz: horizontal integration, vert_silo: vertical integration of whole value chain, multi: multiway integration, Ln TA: log total assets (size), time: linear time trend, reg_us: US, reg_eurp: Europe, reg_ap: Asia Pacific. sigma_u: standard deviation of panel entity-specific time-invariant error term, sigma_e: standard deviation of the idiosyncratic error component, rho: fraction of variance due to u_i.

In beneficial owner (emerging) markets, almost all entities are vertically integrated silo exchanges. Multiway integration is only a developed market phenomenon. Horizontal integration has only one example in the dataset (NSDL of India). Turkish CMIs are also presented as vertically integrated silos as from 2013. Tadawul is the only undifferentiated exchange. Therefore, the effects of horizontal and multiway integration cannot be seen in emerging markets. In addition, all emerging market CMIs used differentiation, so there is no data for comparison to non-differentiated CMIs in emerging markets. Thus, it is more relevant to focus on the entity size.

Table 5.9 presents results for beneficial owner markets (emerging markets). Size significantly reduces average cost in beneficial owner markets (coefficient= -0.0921). Time is insignificant. India and Asia Pacific have significantly lower average costs compared to the rest of the beneficial owner markets, coefficients are -0.5658 and -0.3350 respectively. India has significantly lower average cost compared to Asia Pacific as well (Table B.16). NSDL, the CSD for India also have significantly low average cost. We cannot find effects of differentiation and vertical integration in beneficial owner markets, as most of them are already differentiated vertically integrated silos. Still, our results support that in beneficial owner markets entities use differentiation and vertical integration to increase size.

Size has adverse effects on average cost in non-beneficial owner (developed) and beneficial owner (emerging) markets. This indicates that increasing size does not have further scale and scope economies effects for the developed markets. They are already above a certain level.

Table 5.9 : Random effects GLS regressions for average cost in beneficial owner markets.

AC	Coef.	Std.Err.	z	P>z	[95% Conf. Int.]	
Ln TA	-0.0921	0.0376	-2.4500	0.0140	-0.1658	-0.0185
time	-0.0002	0.0377	-0.0100	0.9950	-0.0741	0.0736
reg_india	-0.5658	0.1080	-5.2400	0.0000	-0.7773	-0.3542
reg_ap	-0.3350	0.0458	-7.3200	0.0000	-0.4247	-0.2453
CSD	-0.3634	0.1507	-2.4100	0.0160	-0.6588	-0.0680
_cons	1.2798	0.3114	4.1100	0.0000	0.6695	1.8901
sigma_u	0.0000					
sigma_e	0.2548					
rho	0.0000					

Random Effects GLS Regression. Group variable: entity, number of obs = 47, number of groups = 11, within R-sq = 0.0397, between R-sq=0.6021, overall R-sq = 0.5284 Wald chi2(5) = 79.99 corr(u_i, X) = 0 (assumed), prob > chi2= 0.0000, standard errors adjusted for 11 clusters in entities. AC: average cost, Ln TA: log total assets (size), time: linear time trend, reg_india: India, reg_ap: Asia Pacific. sigma_u: standard deviation of panel entity-specific time-invariant error term, sigma_e: standard deviation of the idiosyncratic error component, rho: fraction of variance due to u_i.

5.5.3.4 Summary results for short-run costs

Summary results for average cost are presented in Table 5.10. Differentiation reduces average costs of exchanges. Horizontally integrated CMIs have lower average costs compared to vertically integrated (both exchange CCP and silo models) and independent CMIs. There is no significant difference between horizontal and multiway integration. Multiway integration is possible only in non-beneficial owner (developed) markets. It reduces average cost in these markets compared to silo model vertical integration. Entity size significantly reduces average costs in beneficial owner (emerging) markets. Its effect is adverse in non-beneficial owner (developed) markets, as CMIs in these markets are above a certain level. Time is significant in developed markets. US have lower average costs compared to the rest of the world. US and Asia Pacific exchanges have lower average costs compared to Europe, but there is no significant difference between US and Asia Pacific. European exchanges have significantly higher cost compared to the exchanges in the rest of the world.

Table 5.10 : Summary results for average cost (AC).

Variables	**AC**	**AC exchanges**	**AC non-BO**	**AC non-BO exchanges**	**AC BO**
indep	0.4516	-0.0704	0.0249		
horiz	-0.4700	-0.9281**	-0.6345	-0.6696*	
vert_silo	0.0865	0.2251	0.2256	0.3804	
multi	-0.2130	-0.2893	-0.3263*	-0.2489	
diff	-0.3638	-0.9781**	-0.1308	-1.1069*	
ICSD	1.7577		1.3522		
Ln TA	0.0649*	0.0014	0.0929*	0.0366	-0.0921**
time	-0.0665**	-0.0547	-0.0891**	-0.0848	-0.0002
reg_us	-0.7918**	-0.8887**	-0.5734	-1.0787	
reg_eurp	0.0947	0.5183	0.2205	0.3073	
reg_ap	-0.45034**	-0.4700**	-0.5198	-0.6946	-0.3350***
reg_india	-0.1963	-0.2514			-0.5658***
bo	-0.3399	-0.3983	bo=0	bo=0	bo=1
exch	0.3290	exch=1	0.3560	exch=1	
CSD	0.2800	CSD=0	0.7820	CSD=0	-0.3634**
constant	0.3434	1.6390***	-0.0702	1.5525***	1.2798***
sigma_u	0.7152	0.437	0.9574	0.6292	0.0000
sigma_e	0.2725	0.269	0.2873	0.2871	0.2548
rho	0.8733	0.725	0.9174	0.8277	0.0000
number of observations	161	109	114	69	47
number of groups	34	22	23	14	11
within R-sq	0.1791	0.1894	0.1927	0.1743	0.0397
between R-sq	0.5741	0.6304	0.5464	0.6108	0.6021
overall R-sq	0.5623	0.5758	0.5266	0.5684	0.5284
prob > chi2	0.0000	0.0000	0.0000	0.0000	0.0000
Wald chi2	59.06	157.12	61.44	81.00	79.99

AC: average cost, non-BO non beneficial owner markets, BO: beneficial owner markets, diff: product differentiation in terms of asset class, indep: independent, horiz: horizontal integration, vert_silo: vertical integration of whole value chain, multi: multiway integration, Ln TA: log total assets, time: linear time trend, reg_us: USA, reg_eurp: Europe, reg_ap: Asia Pacific, reg_india: India, bo: beneficial owner market, exch: exchange. sigma_u: standard deviation of panel entity-specific time-invariant error term, sigma_e: standard deviation of the idiosyncratic error component, rho: fraction of variance due to u_i. *** significant with p-value≤ 0.01, **significant with p- value≤ 0.05, *significant with p-value≤ 0.10.

5.5.4 Long-run costs and economies of scale

In this section, we first present calculation of securities, derivatives and total scale elasticity coefficients. The coefficients are also graphically presented. The scale coefficients show utilization of cost saving potential due to scale economies. We use panel data GLS regression to assess the effects of the integration, region, size and time on utilization of long run cost saving potential.

5.5.4.1 Calculation of scale elasticities

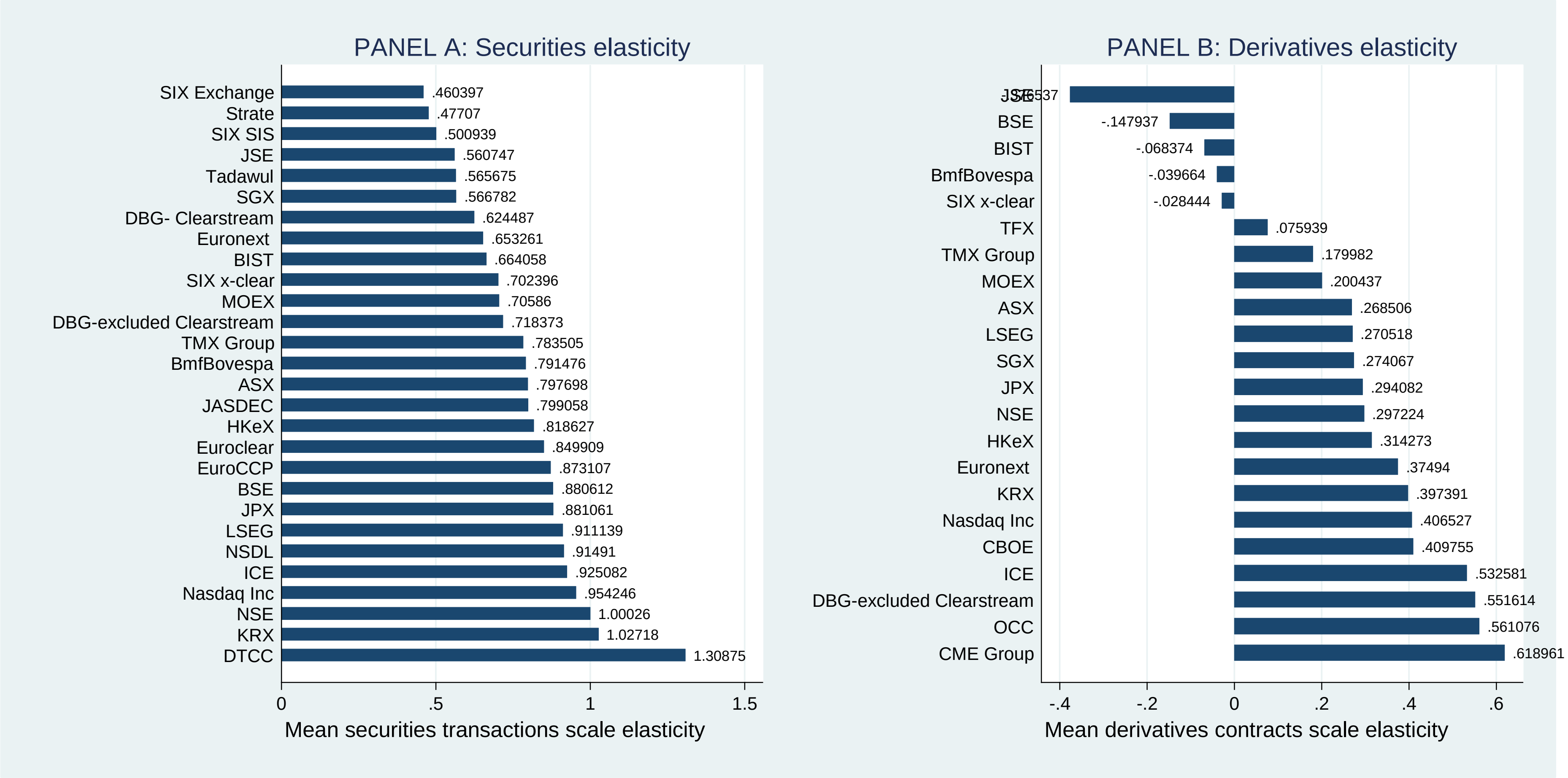
Calculation of cost output elasticity of securities transactions and derivatives contracts processed ($\varepsilon_{sec}= \partial LnTC/\partial Q_{sec}$, $\varepsilon_{d}= \partial LnTC/\partial Q_{d}$) as well as the calculation of Ray scale elasticity coefficients (scale elasticity) is presented in Table 5.11. Output coefficients of the total cost functions, which are significant at 95 % confidence level, are included in order to have robust results. For robustness check elasticities are also calculated with all coefficients. The results of regressions are robust (Table C.6).

Table 5.11 : Calculation of scale elasticity coefficients.

Elasticity	Formula
ε_{secit}	0.0616 *2* Ln ($Qsec_{it}$)
ε_{dit}	0.0606*2* Ln (Qd_{it}) -1.7617 + 0.1203*Ln (P_{it})
$scale_{it}$	$\varepsilon_{secit} + \varepsilon_{dit}$

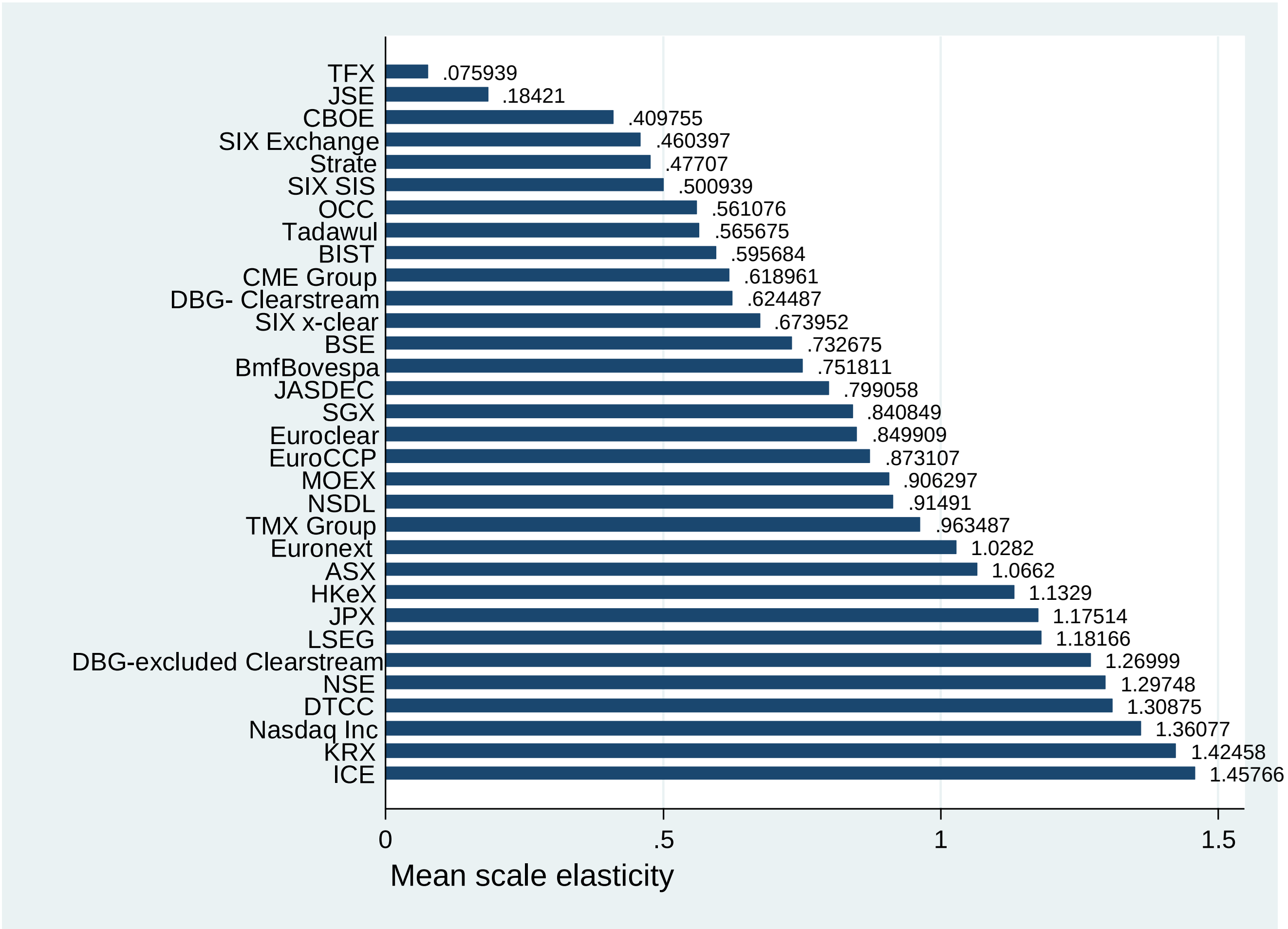
Scale elasticity of securities transactions and derivatives contracts processed (ε_{sec}, ε_{d}) are presented in Figure 5.10. Output elasticity is higher in securities transactions compared to derivatives contracts. This indicates that there is more cost saving potential with increasing the scale of derivatives outputs. Especially beneficial owner markets are associated with low or even negative scale elasticity for derivatives. JSE of South Africa, BSE in India, BIST of Turkey, BmfBovespa of Brazil and SIX x-clear of Switzerland have negative scale elasticity for derivatives output, in these CMIs output scale is extremely low compared to their costs. All these CMIs have securities divisions as well. They compensate the low scale in derivatives with higher scale in securities.

Mean scale elasticity coefficients are presented in Figure 5.11. Scale elasticity is the measure of utilization of cost saving potential due to economies of scale.



Note: Years 2012-2016.

Figure 5.11 : Securities transactions and derivatives contracts cost scale elasticity coefficients.



Note: Years 2012-2016.

Figure 5.12 : Total cost output scale elasticity coefficients.

ICE, KRX, Nasdaq Inc., DTCC, NSE, DBG, LSEG, JPX, HKEX, ASX and Euronext, have highest scale elasticity which are greater than 1. These CMIs overuses the gains from scale and at their current point increasing their scale by 1% increases their costs more than 1%. They passed the optimal output level. TMX Group, NSDL, MOEX, EuroCCP, and Euroclear have scale elasticity over 0.85 and benefit from economies of scale. On the other side TFX and JSE stay in the bottom with limited utilization of economies of scale and they have highest unused cost saving potential with an increase in output scale.

5.5.4.2 Findings for total scale elasticity

Tables 5.11 to 5.22 show the results of regressions for scale elasticity against integration, region, entity type, company size and time effects. Among integration variables, independent (indep) indicates non-integrated CMIs. CBOE is the only non-integrated exchange in our dataset; it only has derivatives contracts trade execution as output. MKK is non-integrated only for year 2012. Euronext is the only horizontally integrated exchange in the dataset; it has both securities and derivatives trade execution. Seven post-trade institutions are horizontally integrated (Jasdec, EuroCCP, Euroclear, NSDL, Strate, OCC, Takasbank). TFX of Japan, NSE of India and JSE of South Africa are the exchanges with CCP integration. There are eight multiway and 13 are silo model vertically integrated CMIs in the dataset. As the five integration models; namely independence (no integration), horizontal, vertical exchange CCP, vertical silo and multiway integration, are mutually exclusive, all cannot be presented in the same regression due to computational issues, otherwise collinearity occurs. Therefore, the integration models, which have low number of observations and insignificant are omitted.

Results for utilization of cost saving potential due to total scale economies are presented in Tables 5.12, 5.13, 5.14 and 5.15. Table 5.12 presents results for the whole dataset, Table 5.13 for CMI in non-beneficial owner markets, Table 5.14 for exchanges in non-beneficial owner markets and Table 5.15 for CMIs in beneficial owner markets.

As Table 5.12 indicates, our results reveal positive and significant relationship of utilization of cost saving potential of scale economies (scale) with integration in general. Independent CMIs have significantly lower use of scale economies (coefficient= -0.6234). Vertical integration in silo model and multiway integration have significant positive effects on the use of scale economies compared to the exchanges vertically integrated with CCPs, their coefficients are 0.1074 and 0.1092 respectively. However, the coefficients of horizontal, vertical silo and multiway integration are not significantly different (Table C.7). Entity size also increases use of economies of scale significantly with coefficient 0.0239. Time increases use of scale economies with coefficient 0.0095, the significance level is low (p-value= 0.073). Effects geographical region are insignificant. CSDs have significantly higher but ICSDs significantly lower use of economies of scale; coefficients are 0.3861 and -0.5207 respectively.

Table 5.12 : Random effects GLS regressions for total scale elasticity.

scale	Coef.	Std.Err.	z	P>z	[95% Conf. Int.]	
diff	-0.0250	0.0996	-0.2500	0.8020	-0.2203	0.1702
indep	-0.6234	0.1068	-5.8400	0.0000	-0.8327	-0.4142
horiz	0.0250	0.1129	0.2200	0.8250	-0.1962	0.2462
vert_silo	0.1074	0.0322	3.3400	0.0010	0.0444	0.1704
multi	0.1092	0.0345	3.1600	0.0020	0.0415	0.1768
Ln TA	0.0239	0.0105	2.2800	0.0230	0.0033	0.0444
time	0.0095	0.0053	1.7900	0.0730	-0.0009	0.0199
reg_us	0.3019	0.2457	1.2300	0.2190	-0.1797	0.7835
reg_eurp	0.2991	0.2369	1.2600	0.2070	-0.1651	0.7633
reg_ap	0.1967	0.2210	0.8900	0.3740	-0.2365	0.6298
reg_india	0.1508	0.1946	0.7700	0.4390	-0.2307	0.5322
bo	0.1824	0.1998	0.9100	0.3610	-0.2093	0.5740
exch	0.2571	0.1435	1.7900	0.0730	-0.0243	0.5384
CSD	0.3861	0.1614	2.3900	0.0170	0.0697	0.7024
ICSD	-0.5207	0.2258	-2.3100	0.0210	-0.9633	-0.0782
_cons	0.1535	0.2558	0.6000	0.5480	-0.3478	0.6548
sigma_u	0.2469					
sigma_e	0.0456					
rho	0.9670					

Random Effects GLS Regression. Group variable: entity, number of obs = 161, number of groups = 34, within R-sq = 0.6849, between R-sq= 0.3365, overall R-sq = 0.3435, Wald chi2(15) = 1259.51, corr(u_i, X) = 0 (assumed), prob > chi2= 0.0000, standard errors adjusted for 34 clusters in entities. scale: total scale elasticity, diff: product differentiation, indep: independent, horiz: horizontal integration, vert_silo: vertical integration of whole value chain, multi: multiway integration, Ln TA: log total assets, time: linear time trend, reg_us: USA, reg_eurp: Europe, reg_ap: Asia Pacific, reg_india: India, bo: market beneficial ownership type, exch: exchange. sigma_u: standard deviation of panel entity-specific time-invariant error term, sigma_e: standard deviation of the idiosyncratic error component, rho: fraction of variance due to u_i.

Diagnostic tests are presented in Appendix C. Serial correlations could not be rejected. Still it is not an issue for micro panels less than 20 years (Baltagi, 2013). In addition we use the models to interpret the availability and direction of effects of independent variables on the dependent variable, we do not make forecasts. Therefore, we are contented with the robustness of our results.

Results for utilization of cost saving potential of total scale elasticity for CMIs in non-beneficial owner markets are presented in Table 5.13. Differentiation significantly reduces the utilization of scale economies with coefficient -0.0986. Integration of any kind significantly increases the use of scale economies, coefficient for non-integration is -0.5584. Silo model vertical integration and multiway integrations are also significant compared to the exchange CCP integration, with coefficients 0.1040 and 0.1031 respectively. However, the coefficients of horizontal, vertical silo and multiway integration are not significantly different (Table C.7). Entity size are insignificant. Use of economies of scale increases over time significantly, the coefficient is 0.0151. Region variables are insignificant. Exchanges uses scale economies significantly with coefficient 0.3624.

Table 5.13 : Random effects GLS regressions for total scale elasticity in non-beneficial owner markets.

scale	**Coef.**	**Std.Err.**	**z**	**P>z**	**[95% Conf. Int.]**	
diff	-0.0986	0.0438	-2.2500	0.0240	-0.1844	-0.0128
indep	-0.5584	0.2567	-2.1800	0.0300	-1.0614	-0.0553
horiz	0.0918	0.1115	0.8200	0.4100	-0.1267	0.3103
vert_silo	0.1040	0.0162	6.4200	0.0000	0.0722	0.1357
multi	0.1031	0.0268	3.8400	0.0000	0.0505	0.1556
Ln TA	0.0133	0.0116	1.1500	0.2510	-0.0094	0.0360
time	0.0151	0.0031	4.9300	0.0000	0.0091	0.0211
reg_us	0.2082	0.3158	0.6600	0.5100	-0.4108	0.8271
reg_eurp	0.1936	0.2826	0.6900	0.4930	-0.3602	0.7474
reg_ap	0.0531	0.2886	0.1800	0.8540	-0.5124	0.6187
exch	0.3624	0.1774	2.0400	0.0410	0.0148	0.7101
CSD	0.2704	0.2332	1.1600	0.2460	-0.1867	0.7275
ICSD	-0.3570	0.2784	-1.2800	0.2000	-0.9027	0.1886
_cons	0.2877	0.2828	1.0200	0.3090	-0.2666	0.8419
sigma_u	0.2092					
sigma_e	0.0259					
rho	0.9849					

Random Effects GLS Regression. Group variable: entity, number of obs = 114, number of groups = 23, within R-sq = 0.6296, between R-sq= 0.2333, overall R-sq = 0.2354, Wald chi2(13) = 572.99, corr(u_i, X) = 0 (assumed), prob > chi2= 0.0000, standard errors adjusted for 23 clusters in entities. scale: Ray scale elasticity, diff: product differentiation, indep: independent, horiz: horizontal integration, vert-silo: vertical integration of whole value chain, multi: multiway integration, Ln TA: log total assets, time: linear time trend, reg_us: USA, reg_eurp: Europe, reg_ap: Asia Pacific, exch: exchange. sigma_u: standard deviation of panel entity-specific time-invariant error term, sigma_e: standard deviation of the idiosyncratic error component, rho: fraction of variance due to u_i.

Results for utilization of cost saving potential of total scale elasticity for exchanges in non-beneficial owner markets are presented in Table 5.14. Differentiation significantly increases use of scale economies with coefficient 0.8357. Silo model vertical and multiway integrations are also significant with coefficients 0.1131 and 0.0907 respectively. Their coefficients are significant compared to independent, horizontally integrated or CCP integrated exchanges in developed markets. However there is no significant difference between vertical silo integration and multiway integration (Table C.7). Other integration models as well as entity size are insignificant. Use of scale economies increases over time significantly with coefficient 0.0136. In the US use of scale economies is available with coefficient 0.5331, significance level is low (p-value=0.06). Other region variables are insignificant.

Table 5.14 : Random effects GLS regressions for total scale elasticity for exchanges in non-beneficial owner markets.

scale	**Coef.**	**Std.Err.**	**z**	**P>z**	**[95% Conf. Int.]**	
diff	0.8357	0.0560	14.9100	0.0000	0.7258	0.9455
horiz	-0.0815	0.0640	-1.2700	0.2030	-0.2069	0.0439
vert_silo	0.1131	0.0091	12.4300	0.0000	0.0953	0.1310
multi	0.0907	0.0270	3.3600	0.0010	0.0377	0.1437
Ln TA	0.0139	0.0132	1.0500	0.2920	-0.0120	0.0398
time	0.0136	0.0040	3.3900	0.0010	0.0057	0.0214
reg_us	0.5331	0.2834	1.8800	0.0600	-0.0224	1.0887
reg_eurp	0.3447	0.2849	1.2100	0.2260	-0.2138	0.9031
reg_ap	0.2033	0.2799	0.7300	0.4680	-0.3453	0.7518
_cons	-0.2006	0.2856	-0.7000	0.4820	-0.7602	0.3591
sigma_u	0.2248					
sigma_e	0.0284					
rho	0.9842					

Random Effects GLS Regression. Group variable: entity, number of obs = 69, number of groups = 19, within R-sq = 0.6162, between R-sq= 0.7835, overall R-sq = 0.7818, Wald chi2(9) = 7600.10, corr(u_i, X) = 0 (assumed), prob > chi2= 0.0000, standard errors adjusted for 19 clusters in entities. scale: total scale elasticity, diff: product differentiation, horiz: horizontal integration, vert-silo: vertical integration of whole value chain, multi: multiway integration, Ln TA: log total assets, time: linear time trend, reg_us: USA, reg_eurp: Europe, reg_ap: Asia Pacific, exch: exchange. sigma_u: standard deviation of panel entity-specific time-invariant error term, sigma_e: standard deviation of the idiosyncratic error component, rho: fraction of variance due to u_i.

Results for utilization of cost saving potential of total scale elasticity in beneficial owner markets are presented in Table 5.15. In beneficial owner markets, almost all CMIs are differentiated and vertically integrated in silo model. NSE (vertically integrated exchange with CCP) and NSDL (horizontal integrated CSD) of India are the only exceptions in terms of the integration structure. Tadawul of Saudi Arabia is the only non-differentiated exchange with securities transactions only. This is mainly due to the fact that derivatives transactions are restricted in this market. Therefore, entity size is the main driver for scale economies and integration in beneficial owner markets. Use of scale economies significantly increases with entity size. Asia Pacific has the highest use of scale economies, India follows (Table C.7).

Table 5.15 : Random effects GLS regressions for derivatives scale elasticity in beneficial owner markets.

scale	**Coef.**	**Std.Err.**	**z**	**P>z**	**[95% Conf. Int.]**	
Ln TA	0.0984	0.0281	3.5100	0.0000	0.0434	0.1534
time	0.0061	0.0208	0.2900	0.7690	-0.0347	0.0469
reg_india	0.3699	0.1378	2.6800	0.0070	0.0998	0.6400
reg_ap	0.6171	0.0467	13.2100	0.0000	0.5255	0.7086
CSD	0.2157	0.1579	1.3700	0.1720	-0.0939	0.5253
_cons	-0.0839	0.2276	-0.3700	0.7130	-0.5299	0.3622
sigma_u	0.1670					
sigma_e	0.1284					
rho	0.6283					

Random Effects GLS Regression. Group variable: entity, number of obs = 47, number of groups = 11, within R-sq = 0.1664, between R-sq= 0.8018, overall R-sq = 0.6919, Wald chi2(5) = 849.79, corr(u_i, X) = 0 (assumed), prob > chi2= 0.0000, standard errors adjusted for 11 clusters in entities. scale: total scale elasticity, Ln TA: log total assets, time: linear time trend, reg_india: India, exch: exchange. sigma_u: standard deviation of panel entity-specific time-invariant error term, sigma_e: standard deviation of the idiosyncratic error component, rho: fraction of variance due to u_i.

5.5.4.3 Findings for securities scale elasticity

Results for utilization of cost saving potential due to scale economies in securities transactions processed are presented in Tables 5.16, 5.17 and 5.18. Table 5.16 presents results for the whole dataset, Table 5.17 for CMIs in non-beneficial owner markets, and Table 5.18 for exchanges in non-beneficial owner markets. Panel regression diagnostics are provided in the Appendix C.

Table 5.16 presents the results for utilization of cost saving potential of scale elasticity in securities transactions processed. Differentiation increases securities output scale elasticity with coefficient 0.0202, significance is low (p-value= 0.084). Vertical integration in silo model and multiway integration are have significant positive effects on the use of scale economies compared to independent CMIs and vertical integrated in exchanges with CCPs, their coefficients are 0.0660 and 0.0554 respectively. The coefficients of vertical silo and multiway integration are not significantly different. Entity size is insignificant. Time increases use of scale economies with coefficient 0.0149. Effects geographical region are significant for US, Asia Pacific and India with coefficients 0.4303, 0.1849 and 0.295 respectively. Europe does not have any significant use of economies of scale. US, Asia Pacific and India have higher securities elasticity coefficients compared to Europe; there is no significant difference among coefficients of US, Asia Pacific and India regions. Still, securities scale elasticity in US region is significantly higher than rest of the dataset (Table C.8). Entity type and market beneficial ownership types are also insignificant.

Table 5.16 : Random effects GLS regressions for securities scale elasticity.

ε_{sec}	**Coef.**	**Std.Err.**	**z**	**P>z**	**[95% Conf. Int.]**	
diff	0.0202	0.0117	1.7300	0.0840	-0.0027	0.0430
indep	-0.0246	0.0219	-1.1200	0.2610	-0.0676	0.0183
horiz	0.0386	0.0709	0.5400	0.5860	-0.1004	0.1776
vert_silo	0.0660	0.0192	3.4400	0.0010	0.0283	0.1037
multi	0.0554	0.0144	3.8600	0.0000	0.0272	0.0835
Ln TA	0.0043	0.0033	1.3100	0.1900	-0.0021	0.0108
time	0.0149	0.0022	6.7100	0.0000	0.0105	0.0192
reg_us	0.4303	0.1744	2.4700	0.0140	0.0885	0.7721
reg_eurp	0.0352	0.1106	0.3200	0.7500	-0.1816	0.2519
reg_ap	0.1849	0.0858	2.1600	0.0310	0.0169	0.3530
reg_india	0.2950	0.0619	4.7600	0.0000	0.1736	0.4163
bo	-0.0109	0.0869	-0.1300	0.9000	-0.1812	0.1594
exch	-0.0438	0.0872	-0.5000	0.6160	-0.2146	0.1271
CSD	-0.0292	0.1082	-0.2700	0.7880	-0.2413	0.1830
ICSD	-0.0562	0.1529	-0.3700	0.7130	-0.3558	0.2435
_cons	0.5818	0.1168	4.9800	0.0000	0.3529	0.8108
sigma_u	0.1241					
sigma_e	0.0205					
rho	0.9735					

Random Effects GLS Regression. Group variable: entity, number of obs = 141, number of groups = 30, within R-sq = 0.6886, between R-sq= 0.5645, overall R-sq = 0.5447, Wald chi2(15) = 30998.74, corr(u_i, X) = 0 (assumed), prob > chi2= 0.0000, standard errors adjusted for 30 clusters in entities. $\boldsymbol{\varepsilon_{sec}}$: securities output scale elasticity, diff: product differentiation, indep: independent, horiz: horizontal integration, vert-silo: vertical integration of whole value chain, multi: multiway integration, Ln TA: log total assets, time: linear time trend, reg_us: USA, reg_eurp: Europe, reg_ap: Asia Pacific, reg_india: India, bo: market beneficial ownership type, exch: exchange. sigma_u: standard deviation of panel entity-specific time-invariant error term, sigma_e: standard deviation of the idiosyncratic error component, rho: fraction of variance due to $u_{i.}$

Results for utilization of cost saving potential of securities scale elasticity in non-beneficial owner markets are presented in Table 5.17. Differentiation is insignificant. Silo model vertical integration and multiway integrations are significant compared to vertical integration of exchange with CCP and non-integration. Their coefficients are 0.0672 and 0.0458 respectively. There is no statistical difference between vertical silo, horizontal and multiway integrations (Table C.8). Entity size is insignificant. Use of economies of scale increases over time significantly, the coefficient is 0.0175. In the US use of scale economies in securities the most (Table C.8), its coefficient is 0.4166. Other region variables and entity type are insignificant.

Table 5.17 : Random effects GLS regressions for securities scale elasticity in non-beneficial owner markets.

ε_{sec}	**Coef.**	**Std.Err.**	**z**	**P>z**	**[95% Conf. Int.]**	
diff	0.0105	0.0085	1.2400	0.2160	-0.0061	0.0271
horiz	0.0763	0.0981	0.7800	0.4370	-0.1160	0.2686
vert_silo	0.0672	0.0119	5.6300	0.0000	0.0438	0.0906
multi	0.0458	0.0093	4.9000	0.0000	0.0275	0.0641
Ln TA	0.0038	0.0045	0.8600	0.3900	-0.0049	0.0126
time	0.0175	0.0024	7.3300	0.0000	0.0128	0.0222
reg_us	0.4166	0.2009	2.0700	0.0380	0.0229	0.8104
reg_eurp	-0.0410	0.1342	-0.3100	0.7600	-0.3040	0.2221
reg_ap	0.1048	0.0991	1.0600	0.2900	-0.0894	0.2991
exch	-0.1091	0.1064	-1.0300	0.3050	-0.3175	0.0994
CSD	-0.1352	0.1884	-0.7200	0.4730	-0.5043	0.2340
ICSD	0.0022	0.2166	0.0100	0.9920	-0.4223	0.4266
_cons	0.6957	0.1375	5.0600	0.0000	0.4262	0.9653
sigma_u	0.1438					
sigma_e	0.0173					
rho	0.9857					

Random Effects GLS Regression. Group variable: entity, number of obs = 94, number of groups = 19, within R-sq = 0.7786, between R-sq= 0.4886, overall R-sq = 0.4947, Wald chi2(12) = 911.42, corr(u_i, X) = 0 (assumed), prob > chi2= 0.0000, standard errors adjusted for 19 clusters in entities. ε_{sec}: securities output elasticity, diff: product differentiation, horiz: horizontal integration, vert_silo: vertical integration of whole value chain, multi: multiway integration, Ln TA: log total assets, time: linear time trend, reg_us: USA, reg_eurp: Europe, reg_ap: Asia Pacific, exch: exchange. sigma_u: standard deviation of panel entity-specific time-invariant error term, sigma_e: standard deviation of the idiosyncratic error component, rho: fraction of variance due to u_i.

Results for utilization of cost saving potential of securities scale elasticity for exchanges in non-beneficial owner markets are presented in Table 5.18. All securities exchanges are differentiated and have some form of integration therefore differentiation and no integration variables are not included in the model. Silo model vertical and multiway integrations are also significant with coefficients 0.0717 and 0.0566 respectively. There is no significant difference between the coefficients of vertical silo and multiway integration. US uses scale elasticity significantly better than Europe and Asia Pacific (Table C.8). Entity size is insignificant. Use of scale economies increases over time significantly with coefficient 0.0145.

Table 5.18 : Random effects GLS regressions for securities scale elasticity for exchanges in non-beneficial owner markets.

εsec	Coef.	Std.Err.	z	P>z	[95% Conf. Int.]	
vert_silo	0.0717	0.0149	4.8000	0.0000	0.0424	0.1010
multi	0.0566	0.0127	4.4600	0.0000	0.0317	0.0814
Ln TA	0.0051	0.0038	1.3300	0.1850	-0.0024	0.0126
time	0.0145	0.0022	6.6500	0.0000	0.0102	0.0188
reg_us	0.1257	0.0897	1.4000	0.1610	-0.0502	0.3016
reg_eurp	-0.0972	0.1216	-0.8000	0.4240	-0.3355	0.1411
reg_ap	0.0329	0.0910	0.3600	0.7180	-0.1456	0.2113
_cons	0.6576	0.0874	7.5300	0.0000	0.4863	0.8289
sigma_u	0.0781					
sigma_e	0.0135					
rho	0.9709					

Random Effects GLS Regression. Group variable: entity, number of obs = 54, number of groups = 11, within R-sq = 0.8408, between R-sq= 0.4084, overall R-sq = 0.4151, Wald chi2(7) = 269.63, corr(u_i, X) = 0 (assumed), prob > chi2= 0.0000, standard errors adjusted for 11 clusters in entities. ε_{sec}= securities output scale elasticity, diff: product differentiation, horiz: horizontal integration, vert-silo: vertical integration of whole value chain, multi: multiway integration, Ln TA: log total assets, time: linear time trend, reg_us: USA, reg_eurp: Europe, reg_ap: Asia Pacific, exch: exchange. sigma_u: standard deviation of panel entity-specific time-invariant error term, sigma_e: standard deviation of the idiosyncratic error component, rho: fraction of variance due to u_i.

5.5.4.4 Findings for derivatives scale elasticity

Results for utilization of cost saving potential due to scale economies in derivatives contracts processed are presented in Tables 5.19, 5.20 and 5.21. Table 5.19 presents results for the whole dataset, Table 5.20 for CMIs in non-beneficial owner markets, and Table 5.21 for exchanges in non-beneficial owner markets. Panel regression diagnostics are provided in the Appendix C.

Results for utilization of cost saving potential of derivatives output scale elasticity are presented in Table 5.19. Differentiation is insignificant. Integration of any kind increases the use of scale economies in derivatives output, coefficient for non-integration is -0.4051. Horizontal and silo model vertical integrations are also significant with coefficients 0.2232 and 0.03282 respectively. All are significantly different from each other (Table C.9). Scale economies in derivatives is used more under horizontal integration compared to vertical (both silo and exchange CCP) and multiway integrations (Table C.9). Entity size increases use of economies of scale with coefficient 0.0220, the significance level is low (p-value=0.069). Time is insignificant. Among regions, US uses scale economies in derivatives the most (Table C.9). Market beneficial owner type is insignificant. Exchanges uses scale economies in derivatives significantly with coefficient 0.3348.

Table 5.19 : Random effects GLS regressions for derivatives scale elasticity.

εd	Coef.	Std.Err.	z	P>z	[95% Conf. Int.]	
diff	0.1461	0.1203	1.2200	0.2240	-0.0896	0.3818
indep	-0.4051	0.1204	-3.3600	0.0010	-0.6412	-0.1691
horiz	0.2232	0.0610	3.6600	0.0000	0.1037	0.3427
vert_silo	0.0382	0.0197	1.9400	0.0530	-0.0005	0.0768
multi	0.0235	0.0271	0.8700	0.3850	-0.0296	0.0767
Ln TA	0.0220	0.0121	1.8200	0.0690	-0.0017	0.0457
time	-0.0037	0.0073	-0.5100	0.6090	-0.0180	0.0106
reg_us	0.6999	0.2157	3.2400	0.0010	0.2771	1.1227
reg_eurp	0.2040	0.1611	1.2700	0.2050	-0.1117	0.5197
reg_ap	0.2011	0.1187	1.6900	0.0900	-0.0315	0.4337
reg_india	-0.0113	0.1782	-0.0600	0.9490	-0.3605	0.3379
bo	0.0546	0.1296	0.4200	0.6740	-0.1995	0.3086
exch	0.3348	0.0566	5.9100	0.0000	0.2238	0.4457
_cons	-0.6179	0.2084	-2.9600	0.0030	-1.0264	-0.2094
sigma_u	0.2066					
sigma_e	0.0496					
rho	0.9456					

Random Effects GLS Regression. Group variable: entity, number of obs = 106, number of groups = 23, within R-sq = 0.6265, between R-sq= 0.5878, overall R-sq = 0.5448, Wald chi2(13) = 992.79, corr(u_i, X) = 0 (assumed), prob > chi2= 0.0000, standard errors adjusted for 23 clusters in entities. εd: derivatives output scale elasticity, diff: product differentiation, indep: independent, horiz: horizontal integration, vert-silo: vertical integration of whole value chain, multi: multiway integration, Ln TA: log total assets, time: linear time trend, reg_us: USA, reg_eurp: Europe, reg_ap: Asia Pacific, reg_india: India, bo: market beneficial ownership type, exch: exchange. sigma_u: standard deviation of panel entity-specific time-invariant error term, sigma_e: standard deviation of the idiosyncratic error component, rho: fraction of variance due to u_i.

Results for utilization of cost saving potential of derivatives scale elasticity in non-beneficial owner markets are presented in Table 5.20. Differentiation is insignificant. Horizontal and silo model vertical integrations are significant with coefficients 0.2405 and 0.0220 respectively (compared to exchange CCP vertical integration). Horizontal integration uses scale economies the most significantly compared to other integration categories (Table C.20). Entity size and time are insignificant. In the US use of scale economies in securities is significant with coefficient 0.4166. Among regions, US uses scale economies in derivatives the most (Table C.9).

Results for utilization of cost saving potential of derivatives scale elasticity for exchanges in non-beneficial owner markets are presented in Table 5.21. Silo model vertical integration is significant with coefficients 0.0219 (compared to no integration and exchange CCP integration). Entity size and time are also insignificant.

Table 5.20 : Random effects GLS regressions for derivatives scale elasticity in non-beneficial owner markets.

ε_{sec}	**Coef.**	**Std.Err.**	**z**	**P>z**	**[95% Conf. Int.]**	
diff	0.0336	0.0873	0.3900	0.7000	-0.1375	0.2048
indep	-0.0966	0.0788	-1.2300	0.2200	-0.2511	0.0578
horiz	0.2405	0.0933	2.5800	0.0100	0.0576	0.4234
vert_silo	0.0220	0.0075	2.9500	0.0030	0.0074	0.0366
multi	0.0389	0.0241	1.6200	0.1060	-0.0083	0.0861
Ln TA	0.0115	0.0117	0.9900	0.3230	-0.0113	0.0344
time	0.0022	0.0028	0.7700	0.4400	-0.0034	0.0077
reg_us	0.5137	0.2148	2.3900	0.0170	0.0928	0.9346
reg_eurp	0.1849	0.2151	0.8600	0.3900	-0.2367	0.6066
reg_ap	0.1620	0.1919	0.8400	0.3980	-0.2141	0.5382
exch	0.3058	0.0948	3.2300	0.0010	0.1200	0.4916
_cons	-0.3866	0.2432	-1.5900	0.1120	-0.8632	0.0900
sigma_u	0.1470					
sigma_e	0.0232					
rho	0.9757					

Random Effects GLS Regression. Group variable: entity, number of obs = 70, number of groups = 15, within R-sq = 0.1863, between R-sq= 0.6490, overall R-sq = 0.5896, Wald chi2(11) = 2219.02, corr(u_i, X) = 0 (assumed), prob > chi2= 0.0000, standard errors adjusted for 15 clusters in entities. ε_d: derivatives output elasticity, diff: product differentiation, indep: independent, horiz: horizontal integration, vert-silo: vertical integration of whole value chain, multi: multiway integration, Ln TA: log total assets, time: linear time trend, reg_us: USA, reg_eurp: Europe, reg_ap: Asia Pacific,exch: exchange. sigma_u: standard deviation of panel entity-specific time-invariant error term, sigma_e: standard deviation of the idiosyncratic error component, rho: fraction of variance due to u_i.

Table 5.21 : Random effects GLS regressions for derivatives scale elasticity for exchanges in non-beneficial owner markets.

ε_d	**Coef.**	**Std.Err.**	**z**	**P>z**	**[95% Conf. Int.]**	
diff	0.0807	0.0620	1.3000	0.1930	-0.0407	0.2022
horiz	0.0544	0.1222	0.4500	0.6560	-0.1851	0.2939
vert_silo	0.0219	0.0079	2.7700	0.0060	0.0064	0.0375
multi	0.0360	0.0267	1.3500	0.1780	-0.0164	0.0883
Ln TA	0.0103	0.0124	0.8300	0.4060	-0.0140	0.0346
time	0.0026	0.0031	0.8400	0.4000	-0.0034	0.0086
reg_us	0.4859	0.2041	2.3800	0.0170	0.0858	0.8859
reg_eurp	0.2801	0.2277	1.2300	0.2190	-0.1662	0.7264
reg_ap	0.1750	0.1934	0.9000	0.3660	-0.2042	0.5541
_cons	-0.1178	0.2199	-0.5400	0.5920	-0.5489	0.3132
sigma_u	0.1761					
sigma_e	0.0242					
rho	0.9815					

Random Effects GLS Regression. Group variable: entity, number of obs = 64, number of groups = 13, within R-sq = 0.1839, between R-sq= 0.5785, overall R-sq = 0.5744, Wald chi2(9) = 238.65, corr(u_i, X) = 0 (assumed), prob > chi2= 0.0000, standard errors adjusted for 13 clusters in entities. ε_d= derivatives output scale elasticity, diff: product differentiation, horiz: horizontal integration, vert-silo: vertical integration of whole value chain, multi: multiway integration, Ln TA: log total assets, time: linear time trend, reg_us: USA, reg_eurp: Europe, reg_ap: Asia Pacific, exch: exchange. sigma_u: standard deviation of panel entity-specific time-invariant error term, sigma_e: standard deviation of the idiosyncratic error component, rho: fraction of variance due to u_i.

Use of scale economies is significantly higher in the US compared to Asia Pacific and regions other than Europe and India (Table C.9).

5.5.4.5 Summary results for scale elasticity

Summary results are presented in Table 5.22. No integration reduces benefits from scale economies, especially for derivatives. Therefore, integration of any kind increases long-run scale efficiency. For total scale elasticity coefficients and securities scale elasticity coefficients, silo model vertical integration and multiway integration have significant positive effects on long run cost efficiency compared to the other integration types. But there is no significant difference between vertical silo model integration and multiway integration. On the other side, for derivatives scale elasticity coefficients, coefficient for horizontal integration is highest, vertical silo integration is the second best and no integration is lowest (negative) compared to other groups. Asset class differentiation is significant for exchanges in non-beneficial owner (developed) markets. For regions, overall effects are not clear, however, US is efficient both in securities and derivatives markets. Asia Pacific and India are also scale efficient compared to other emerging markets. Asia Pacific have higher coefficient compared to India. The significance of coefficients against each other are tested in Appendix C (Tables C.7, C.8 and C.9).

For robustness check, all scale coefficients are estimated by using all output coefficients in the translog total cost function. The results reveal that including all coefficients in the translog total cost function does not reduce the significance or alter direction of coefficients of independent variables. There are minor improvements in significance levels. Magnitude of coefficients also change slightly. The repeated summary table is provided in Appendix C (Table C.6).

Table 5.22 : Summary results for utilization of long-run cost saving potential due to economies of scale (scale).

Variables	scale	scale non-BO	scale non-BO exchanges	scale BO	ε_{sec}	ε_{sec} non-BO	ε_{sec} non-BO exchanges	ε_{d}	ε_{d} non-BO	ε_{d} non-BO exchanges
indep	-0.6234***	-0.5584**			-0.0246			-0.4051***	-0.097	
horiz	0.0250	0.0918	-0.0815		0.0386	0.0763		0.2232***	0.2405***	0.0544
vert_silo	0.1074***	0.1040***	0.1131***		0.0660***	0.0672***	0.0717***	0.0382*	0.0220***	0.0219***
multi	0.1091***	0.1031***	0.0907***		0.0554***	0.0458***	0.0566***	0.0235	0.039	0.0360
diff	-0.0250	-0.0986**	0.8357***		0.0202*	0.0105		0.1461	0.034	0.081
ICSD	-0.5207**	-0.3570			-0.0562	0.0022				
Ln TA	0.0239**	0.0133	0.0139	0.0984***	0.0043	0.0038	0.0051	0.0220*	0.012	0.010
time	0.0095*	0.0151***	0.0136***	0.0061	0.0149***	0.0175***	0.0145***	-0.0037	0.002	0.003**
reg_us	0.3019	0.2082	0.5331*		0.4303**	0.4166**	0.1257	0.6999***	0.5137**	0.4859**
reg_eurp	0.2991	0.1936	0.3447		0.0352	-0.0410	-0.0972	0.2040	0.185	0.280
reg_ap	0.1967	0.0531	0.2033	0.6171***	0.1849**	0.1048	0.0329	0.2011*	0.162	0.175
reg_india	0.1508			0.3699***	0.2950***			-0.0113		
bo	0.1824	*bo=0*	*bo=0*	*bo=1*	-0.0109	*bo=0*	*bo=0*	0.0546	*bo=0*	*bo=0*
exch	0.2571*	0.3624**	*exch=1*		-0.0438	-0.1091	*exch=1*	0.3348***	0.3058***	*exch=1*
CSD	0.3861**	0.2704		0.2157	-0.0292	-0.1352				
constant	0.1535	0.2877	-0.2006	-0.0839	0.5818	0.6957***	0.6576***	-0.6179***	-0.387	-0.118
sigma_u	0.2469	0.2092	0.2248	0.1670	0.1241	0.1438	0.0781	0.207	0.147	0.176
sigma_e	0.0456	0.0259	0.0284	0.1284	0.0205	0.0173	0.0135	0.050	0.023	0.024
rho	0.9670	0.9849	0.9842	0.6283	0.9735	0.9857	0.9709	0.946	0.976	0.982

Table 5.22 (continued): Summary results for utilization of long-run cost saving potential due to economies of scale (scale).

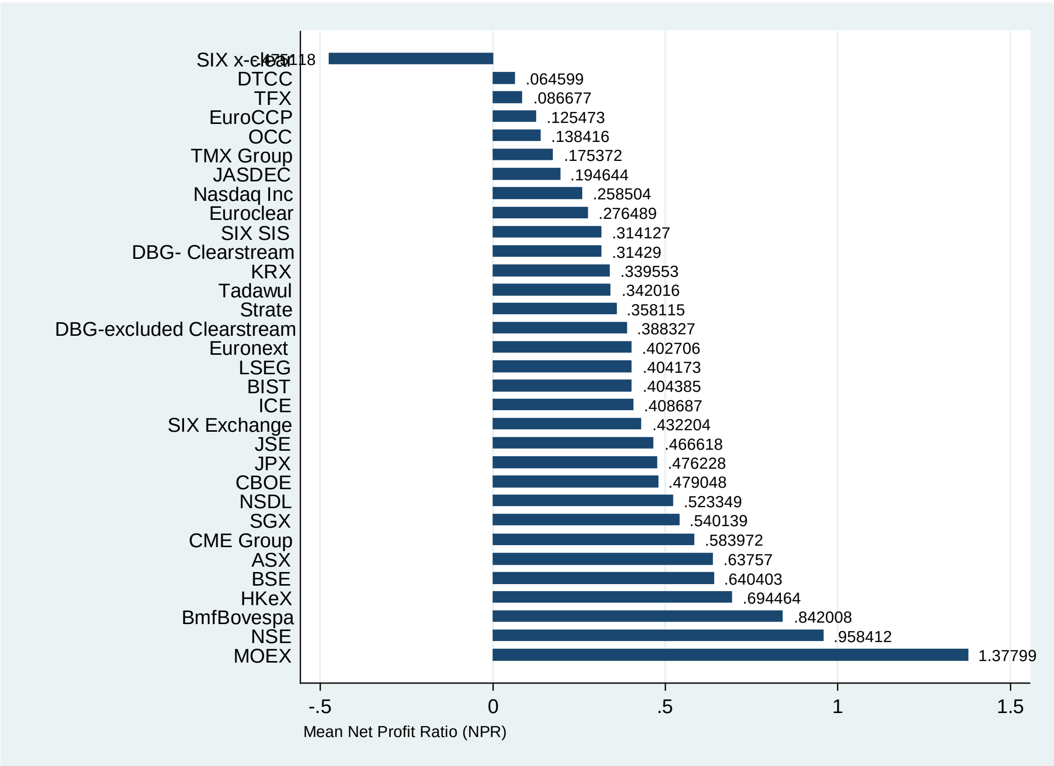
Variables	scale	scale non-BO	scale non-BO exchanges	scale BO	ε_{sec}	ε_{sec} non-BO	ε_{sec} non-BO exchanges	ε_d	ε_d non-BO	ε_d non-BO exchanges
number of observations	161	114	69	47	141	94	54	106	70	64
number of groups	34	23	19	11	30	19	11	23	15	13
within R-sq	0.6849	0.6296	0.6162	0.1664	0.6886	0.7786	0.8408	0.6265	0.1863	0.1839
between R-sq	0.3365	0.2333	0.7835	0.8018	0.5645	0.4886	0.4084	0.5878	0.6490	0.5785
overall R-sq	0.3435	0.2354	0.7818	0.6919	0.5447	0.4947	0.4151	0.5448	0.5896	0.5744
prob > chi2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Wald chi2	1259.51	572.99	7600.10	849.79	30998.74	911.42	269.63	992.79	2219.02	238.65

scale: total scale elasticity, ε_{sec}: securities scale elasticity, ε_d: derivatives scale elasticity, non-BO non beneficial owner markets, BO: beneficial owner markets, diff: product differentiation in terms of asset class, indep: independent, horiz: horizontal integration, vert_silo: vertical integration of whole value chain, multi: multiway integration, Ln TA: log total assets, time: linear time trend, reg_us: USA, reg_eurp: Europe, reg_ap: Asia Pacific, reg_india: India, bo: beneficial owner market, exch: exchange. Parenthesis indicate coefficients with p-value between 0.05 and 0.1. *** Significant with p-value$\leq$ 0.01, **significant with p- value $\leq$ 0.05, *significant with p-value$\leq$ 0.10.

5.5.5 Profitability

Net profit ratio (NPR) is calculated as net income divided by the total revenue. It is an indicator of profitability and pricing power of the CMI.

As seen from Figure 5.12, MOEX of Russia, NSE and BSE of India, BmfBovespa of Brazil and HKEX and ASX in the Asia Pacific region have highest pricing power. All of these institutions except India are associated with nationwide vertical integration. NSE and BSE of India on the other side are two exchanges available in India. However, the availability of two exchange does not reveal competitive pricing structure though. Indian CMIs have market power and capture a part of the cost saving gains as profits.



Note: Years 2012-2016.

Figure 5.13 : Net Profit Ratio (NPR) per CMI.

SIX x-clear has investment in business development in recent years, therefore, its profits are negative. DTCC and OCC in the US and JASDEC in Japan have the low profitability. They have public utility model and horizontally integrated. Other low profit CMIs operate in markets where competition is enforced. In these markets alternative trade execution, clearing and settlement venues are available. TFX of Japan, EuroCCP in Europe are among them. CME Group and CBOE are the sole derivatives exchanges and they have highest profitability among CMIs in Europe and in the US. However, DBG- excluding Clearstream is the biggest pan European derivatives exchange but its profitability is moderate. TFX of Japan is also among the lowest profitable exchanges.

Tables 5.23 to 5.27 show the relation between NPR and integration as well as product diversification and region variables. Table 5.23 show general results for all CMIs, 5.24 results for exchanges, 5.25 for CMIs in non-beneficial owner markets, 5.26 for exchanges in non-beneficial owner markets and 5.27 CMIs in beneficial owner markets. Regression diagnostics are provided in the Appendix D.

General results for NPR (Table 5.23) reveal that asset class differentiation and horizontal integration are the main drivers for profitability.

Table 5.23 : Random effects GLS regressions for Net Profit Ratio (NPR).

NPR	Coef.	Std.Err.	z	P>z	[95% Conf. Int.]	
diff	0.3760	0.1108	3.3900	0.0010	0.1587	0.5932
data	-0.3078	0.1386	-2.2200	0.0260	-0.5795	-0.0362
indep	0.1233	0.1108	1.1100	0.2660	-0.0939	0.3404
horiz	0.3386	0.1396	2.4300	0.0150	0.0650	0.6122
vert_silo	0.0426	0.0778	0.5500	0.5850	-0.1100	0.1951
multi	0.0532	0.1441	0.3700	0.7120	-0.2292	0.3356
Ln TA	0.0296	0.0357	0.8300	0.4060	-0.0403	0.0995
time	0.0009	0.0126	0.0700	0.9400	-0.0237	0.0256
reg_us	-0.0580	0.2184	-0.2700	0.7910	-0.4861	0.3702
reg_eurp	-0.2189	0.2377	-0.9200	0.3570	-0.6849	0.2470
reg_ap	-0.0754	0.2152	-0.3500	0.7260	-0.4972	0.3464
reg_india	-0.0028	0.1641	-0.0200	0.9860	-0.3244	0.3188
bo	0.3266	0.2062	1.5800	0.1130	-0.0775	0.7308
exch	0.0468	0.2802	0.1700	0.8670	-0.5024	0.5959
dex	0.2746	0.2000	1.3700	0.1700	-0.1175	0.6666
CSD	0.0105	0.2478	0.0400	0.9660	-0.4752	0.4961
ICSD	0.2794	0.2773	1.0100	0.3140	-0.2640	0.8228
_cons	-0.2149	0.3140	-0.6800	0.4940	-0.8303	0.4006
sigma_u	0.2827					
sigma_e	0.1758					
rho	0.7212					

Random Effects GLS Regression. Group variable: entity, number of obs = 161, number of groups = 34, within R-sq = 0.1320, between R-sq= 0.5299, overall R-sq = 0.4044, Wald chi2(17) = 90.46, corr(u_i, X) = 0 (assumed), prob > chi2= 0.0000, standard errors adjusted for 34 clusters in entities. NPR: net profit ratio, diff: product differentiation in terms of asset class, data: product diversification to data and information services, indep: independent, horiz: horizontal integration, vert-silo: vertical integration of whole value chain, multi: multiway integration, Ln TA: log total assets, time: linear time trend, reg_us: USA, reg_eurp: Europe, reg_ap: Asia Pacific, reg_india: India, bo: market beneficial ownership type, exch: exchange, dex: major derivatives exchange. sigma_u: standard deviation of panel entity-specific time-invariant error term, sigma_e: standard deviation of the idiosyncratic error component, rho: fraction of variance due to u_i.

Differentiation and horizontal integration have coefficients 0.3760 and 0.3386 respectively. Diversification to data and information services reduces profitability significantly with coefficient -0.3078.Horizontal integration is significantly profitable if compared to silo model vertical integration and multiway integration categories individually (Table D.7). Time, size, entity type, diversification in the form of ICSD remains insignificant. Major derivatives exchanges are also insignificant. Diagnostic tests are presented in Appendix D. Serial correlations could not be rejected. Still it is not an issue for micro panels less than 20 years (Baltagi, 2013). In addition we use the models to interpret the availability and direction of effects of independent variables on the dependent variable, we do not make forecasts. Therefore, we are contented with the robustness of our results.

Results for NPR of exchanges (Table 5.24) reveal that diversification to data and information services reduces profitability significantly with coefficient -0.3153.

Table 5.24 : Random effects GLS regressions for NPR of exchanges.

NPR	**Coef.**	**Std.Err.**	**z**	**P>z**	**[95% Conf. Int.]**	
diff	0.1568	0.0994	1.5800	0.1140	-0.0379	0.3516
data	-0.3128	0.1584	-1.9700	0.0480	-0.6233	-0.0023
indep	-0.0175	0.1330	-0.1300	0.8950	-0.2782	0.2432
horiz	0.1085	0.1714	0.6300	0.5270	-0.2274	0.4444
vert_silo	0.1368	0.0974	1.4000	0.1600	-0.0541	0.3276
multi	0.0195	0.1767	0.1100	0.9120	-0.3269	0.3659
Ln TA	0.0417	0.0417	1.0000	0.3180	-0.0401	0.1235
time	-0.0090	0.0169	-0.5300	0.5950	-0.0422	0.0242
reg_us	0.1579	0.2536	0.6200	0.5330	-0.3391	0.6550
reg_eurp	-0.0135	0.2106	-0.0600	0.9490	-0.4263	0.3992
reg_ap	-0.0577	0.2215	-0.2600	0.7950	-0.4917	0.3764
reg_india	0.2234	0.2168	1.0300	0.3030	-0.2016	0.6484
bo	0.1856	0.2232	0.8300	0.4060	-0.2518	0.6230
dex	0.0544	0.1879	0.2900	0.7720	-0.3139	0.4226
_cons	-0.1141	0.2799	-0.4100	0.6840	-0.6627	0.4346
sigma_u	0.3164					
sigma_e	0.1698					
rho	0.7764					

Random Effects GLS Regression. Group variable: entity, number of obs = 109, number of groups =22, within R-sq = 0.1282, between R-sq= 0.3599, overall R-sq = 0.3005, Wald chi2(13) = 65.29, corr(u_i, X) = 0 (assumed), prob > chi2= 0.0000, standard errors adjusted for 22 clusters in entities. NPR: net profit ratio, diff: product differentiation in terms of asset class, data: product diversification to data and information services, indep: independent, horiz: horizontal integration, vert-silo: vertical integration of whole value chain, multi: multiway integration, Ln TA: log total assets, time: linear time trend, reg_us: USA, reg_eurp: Europe, reg_ap: Asia Pacific, reg_india: India, bo: market beneficial ownership type, dex: major derivatives exchange. sigma_u: standard deviation of panel entity-specific time-invariant error term, sigma_e: standard deviation of the idiosyncratic error component, rho: fraction of variance due to u_i.

Results for NPR of CMIs in non-beneficial owner markets (Table 5.25) reveal that differentiation, horizontal and multiway integrations are the main drivers for profitability in developed market CMIs. Their coefficients are 0.2844, 0.2882 and 0.2057 respectively. The coefficients of the two categories are not significantly different (Table D.7). Diversification to data and information services reduces profitability significantly with coefficient -0.2627. Other integration variables, time and size are insignificant. Asia pacific region has positive NPR with coefficient 0.2063 compared to regions other than US and Europe; the coefficient is not significantly different from US and Europe (Table D.7). Exchanges are significantly more profitable with coefficient 0.4371. Profitability of major derivatives exchanges are not significant. ICSD are profitable with coefficient 0.3660.

Table 5.25 : Random effects GLS regressions for Net Profit Ratio (NPR) of CMIs in non-beneficial owner markets.

NPR	**Coef.**	**Std.Err.**	**z**	**P>z**	**[95% Conf. Int.]**	
diff	0.2844	0.1399	2.0300	0.0420	0.0101	0.5587
data	-0.2627	0.1095	-2.4000	0.0160	-0.4772	-0.0482
indep	0.0564	0.1763	0.3200	0.7490	-0.2892	0.4020
horiz	0.2882	0.1277	2.2600	0.0240	0.0380	0.5385
vert_silo	0.1157	0.0893	1.3000	0.1950	-0.0592	0.2907
multi	0.2057	0.0618	3.3300	0.0010	0.0845	0.3268
Ln TA	-0.0342	0.0257	-1.3300	0.1830	-0.0845	0.0161
time	0.0113	0.0096	1.1800	0.2380	-0.0075	0.0301
reg_us	0.2467	0.1721	1.4300	0.1520	-0.0906	0.5841
reg_eurp	0.0498	0.1538	0.3200	0.7460	-0.2516	0.3512
reg_ap	0.2063	0.1167	1.7700	0.0770	-0.0225	0.4350
exch	0.4371	0.1781	2.4500	0.0140	0.0879	0.7862
dex	0.1295	0.1587	0.8200	0.4150	-0.1817	0.4406
CSD	0.2131	0.1536	1.3900	0.1650	-0.0880	0.5142
ICSD	0.3660	0.1885	1.9400	0.0520	-0.0034	0.7354
_cons	-0.2082	0.2283	-0.9100	0.3620	-0.6556	0.2393
sigma_u	0.1855					
sigma_e	0.1447					
rho	0.6219					

Random Effects GLS Regression. Group variable: entity, number of obs = 114, number of groups = 23, within R-sq = 0.1787, between R-sq= 0.6277, overall R-sq = 0.5143, Wald chi2(15) = 385.52, corr(u_i, X) = 0 (assumed), prob > chi2= 0.0000, standard errors adjusted for 23 clusters in entities. NPR: net profit ratio, diff: product differentiation in terms of asset class, data: product diversification to data and information services, indep: independent, horiz: horizontal integration, vert_silo: vertical integration of whole value chain, multi: multiway integration, Ln TA: log total assets, time: linear time trend, reg_us: USA, reg_eurp: Europe, reg_ap: Asia Pacific, exch: exchange, dex: major derivatives exchange. sigma_u: standard deviation of panel entity-specific time-invariant error term, sigma_e: standard deviation of the idiosyncratic error component, rho: fraction of variance due to u_i.

Results for NPR of exchanges in non-beneficial owner markets (Table 5.26) reveal that multiway integration is the main driver for profitability in exchanges in non-beneficial owner markets. The coefficient is 0.2099. But it is not significantly different from silo model vertical integration and horizontal integration categories (Table D.7). Diversification to data services significantly reduces NPR with coefficient -0,2641. Exchanges in non-beneficial owner Asia Pacific markets are significantly profitable with coefficient 0.2559.

Table 5.26 : Random effects GLS regressions for Net Profit Ratio (NPR) of exchanges in non-beneficial owner markets.

NPR	Coef.	Std.Err.	z	P>z	[95% Conf. Int.]	
diff	0.1791	0.1455	1.2300	0.2180	-0.1061	0.4644
data	-0.2641	0.1252	-2.1100	0.0350	-0.5094	-0.0188
horiz	-0.0302	0.1742	-0.1700	0.8630	-0.3717	0.3113
vert_silo	0.1301	0.0910	1.4300	0.1530	-0.0483	0.3085
multi	0.2099	0.0527	3.9800	0.0000	0.1066	0.3132
Ln TA	-0.0314	0.0277	-1.1300	0.2580	-0.0857	0.0230
time	0.0030	0.0096	0.3100	0.7560	-0.0159	0.0219
reg_us	0.2954	0.1918	1.5400	0.1240	-0.0806	0.6714
reg_eurp	0.1964	0.1508	1.3000	0.1930	-0.0991	0.4920
reg_ap	0.2559	0.1107	2.3100	0.0210	0.0390	0.4728
dex	0.0515	0.1531	0.3400	0.7370	-0.2486	0.3516
_cons	0.2661	0.2210	1.2000	0.2280	-0.1670	0.6992
sigma_u	0.1580					
sigma_e	0.1013					
rho	0.7085					

Random Effects GLS Regression. Group variable: entity, number of obs = 69, number of groups = 14, within R-sq = 0.2828, between R-sq= 0.4753, overall R-sq = 0.4187, Wald chi2(11) = 175.08, corr(u_i, X) = 0 (assumed), prob > chi2= 0.0000, standard errors adjusted for 14 clusters in entities. NPR: net profit ratio, diff: product differentiation in terms of asset class, data: product diversification to data and information services, horiz: horizontal integration, vert_silo: vertical integration of whole value chain, multi: multiway integration, Ln TA: log total assets, time: linear time trend, reg_us: USA, reg_eurp: Europe, reg_ap: Asia Pacific, reg_india: India, bo: market beneficial ownership type, dex: major derivatives exchange. sigma_u: standard deviation of panel entity-specific time-invariant error term, sigma_e: standard deviation of the idiosyncratic error component, rho: fraction of variance due to u_i.

Results for NPR of exchanges in beneficial owner markets (Table 5.27) reveal that entity size is the main drivers for profitability. The coefficient is 0.2292. CMIs in beneficial owner Asia Pacific markets are significant less profitable (coefficient= -0.6644), Indian CMIs are significantly more profitable (coefficient= 0.1882) compared to other CMIs in beneficial owner markets. The coefficients of Adia Pacific and India are significantly different from each other (Table D.7). The only CSD, NSDL of India is also significantly more profitable (coefficient=0.4156). The results do not alter if the regression is run for exchanges in beneficial owner markets. The results for exchanges in beneficial owner markets are presented in Table D.6 (Appendix D).

Table 5.27 : Random effects GLS regressions for Net Profit Ratio (NPR) of CMIs in beneficial owner markets.

NPR	Coef.	Std.Err.	z	P>z	[95% Conf. Int.]	
Ln TA	0.2292	0.0591	3.8800	0.0000	0.1134	0.3449
time	-0.0460	0.0371	-1.2400	0.2160	-0.1187	0.0268
reg_ap	-0.6644	0.1320	-5.0300	0.0000	-0.9230	-0.4057
reg_india	0.1882	0.0931	2.0200	0.0430	0.0058	0.3706
CSD	0.4156	0.1892	2.2000	0.0280	0.0447	0.7864
_cons	-0.9517	0.4386	-2.1700	0.0300	-1.8113	-0.0921
sigma_u	0.1479					
sigma_e	0.2340					
rho	0.2854					

Random Effects GLS Regression. Group variable: entity, number of obs = 47, number of groups = 11, within R-sq = 0.0889, between R-sq= 0.5455, overall R-sq = 0.5813, Wald chi2(5) = 321.19, corr(u_i, X) = 0 (assumed), prob > chi2= 0.0000, standard errors adjusted for 11 clusters in entities. NPR: net profit ratio, Ln TA: log total assets, time: linear time trend, reg_ap: Asia Pacific, reg_india: India. sigma_u: standard deviation of panel entity-specific time-invariant error term, sigma_e: standard deviation of the idiosyncratic error component, rho: fraction of variance due to u_i.

Summary results for profitability are presented in Table 28. Horizontal and multiway integration increases the profitability. Horizontal integration is not significantly profitable for exchanges. Therefore, we can attribute the profitability due to horizontal integration to post trade CMIs, CCPs and CSDs. Size increases the profitability in beneficial owner (emerging) markets. Asset class differentiation increases profitability, data and information business lines reduces. ICSDs are also profitable. Asia Pacific beneficial owner markets are less profitable than other beneficial owner markets. India is more profitable.

Table 5.28 : Summary results for net profit ratio (NPR).

Variables	**NPR**	**NPR exchanges**	**NPR Non-BO**	**NPR Non-BO exchange**	**NPR BO**
indep	0.1233	-0.0175	0.0564		
horiz	0.3386**	0.1085	0.2882**	-0.0302	
vert_silo	0.0426	0.1368	0.1157	0.1301	
multi	0.0532	0.0195	0.2057***	0.2099***	
data	-0.3078**	-0.3128**	-0.2627**	-0.2641**	
diff	0.3760***	0.1568	0.2844**	0.1791	
dex	0.2746	0.0544	0.1295	0.0515	
ICSD	0.2794		0.3660*		
Ln TA	0.0296	0.0417	-0.0342	-0.0314	0.2292***
time	0.0009	-0.0090	0.0113	0.0030	-0.0460
reg_us	-0.0580	0.1579	0.2467	0.2954	
reg_eurp	-0.2189	-0.0135	0.0498	0.1964	
reg_ap	-0.0754	-0.0577	0.2063*	0.2559**	-0.6644***
reg_india	-0.0028	0.2234			0.1882**
bo	0.3266	0.1856	*bo=0*	*bo=0*	*bo=1*
exch	0.0468	*exch=1*	0.4371**	*exch=1*	
CSD	0.0105		0.2131		0.4156
constant	-0.2149	-0.1141	-0.2082	0.2661	-0.9517
sigma_u	0.2827	0.3164	0.1855	0.1580	0.1479
sigma_e	0.1758	0.1698	0.1447	0.1013	0.2340
rho	0.7212	0.7764	0.6219	0.7085	0.2854
number of observations	161	109	114	69	47
number of groups	34	22	23	14	11
within R-sq	0.1320	0.1282	0.1787	0.2828	0.0889
between R-sq	0.5299	0.3599	0.6277	0.4753	0.5455
overall R-sq	0.4044	0.3005	0.5143	0.4187	0.5813
prob > chi2	0.0000	0.0000	0.0000	0.0000	0.0000
Wald chi2	90.46	65.29	385.52	175.08	321.19

NPR: net profit ratio (net income/revenues), non-BO non beneficial owner markets, BO: beneficial owner markets, diff: product differentiation in terms of asset class, data: diversification to data business line, indep: independent, horiz: horizontal integration, vert_silo: vertical integration of whole value chain, multi: multiway integration, Ln TA: log total assets, time: linear time trend, reg_us: USA, reg_eurp: Europe, reg_ap: Asia Pacific, reg_india: India, bo: beneficial owner market, exch: exchange, dex: undifferentiated derivatives exchange. Parenthesis indicate coefficients with p-value between 0.05 and 0.1. *** Significant with p-value≤ 0.01, **significant with p- value ≤0.05, *significant with p-value ≤0.10.

5.6 Discussion of the Results

Cost efficiency indicates maximum productivity with minimum wasted expense. Profitability is a measure of market power and consequently pricing efficiency. Therefore, we try to find out the integration model and diversification aspects that increases the efficiency, i.e. reduce costs and profit margins, given the output levels. Output levels are exogenous. Literature on business integration models of CMIs are diverse in findings and arguments. There is no one clear answer that fits all circumstances. Our results shed light on different angles in efficiency analysis. Table 5.3 shows that technical inefficiency is insignificant in the CMI industry. On top of this, the results reveal that diversification, integration, region and type dimensions are significant (Table A.6). These together indicate that diversification, integration, region and type dimensions explains the sources of cost efficiency in excess of output scale. There is no significant cost element independent of scale, integration, diversification, region or type. Therefore, we believe that our cost model captures elements that drives CMIs to business integration and product diversification strategies globally.

In this section, we discuss utilization of economies of scale, effects of business integration, product diversification, geographical regions, and technological development over time, entity size and type on the efficiency of CMIs. This section combine results of our empirical study with the developments in the global landscape and the economic literature on efficiency of CMIs.

5.6.1 Utilization of economies of scale

10 CMIs out of 34 are associated with utilization of economies of scale (Figure 5.11). ICE, KRX, DTCC, Nasdaq Inc., NSE, DBG excluding Clearstream, LSEG, JPX, HKEX, ASX and Euronext have highest scale elasticity which are greater than 1. Among these, DTCC, KRX and NSE have highest scale elasticities in securities transactions, with elasticity over 1 (Figure 5.10 Panel A). This indicates that these CMIs has no further cost reduction potential as their output level increases. They passed the optimal output level. For derivatives maximum scale elasticity is 0.62, this belongs to CME Group (Figure 5.10 Panel B). Scale economies are not utilized in derivatives as much as they are utilized in securities. There are even negative elasticity coefficients. Negative elasticities indicate the output level are very low in these

markets. JSE of South Africa, BSE of India, BIST of Turkey, BmfBovespa of Brazil, and SIX x-clear of Switzerland are these markets.

One sample t-test and Kolmogorov-Smirnov test reveals that the economies of scale is significantly below 1. The CMIs do not utilize cost saving potential of scale economies completely and they have further cost saving potential with increased output volumes on average. Results are presented in Appendix Table C.10 (Appendix C). This suggests the industry is not in long-run equilibrium for most of the data, as also found by Li and Marinč, (2016). Therefore, the results do not support our first hypothesis that economies of scale is available in the industry.

Some CMIs overuse the scale economies and already passed the optimum level while some others have a long way to reach the optimum level. This indicates that there is potential for further mergers and acquisitions or other ways of consolidation as well as potential demergers in order to increase efficiency. However, increasing the cost efficiency is not the only primary focus of the CMIs themselves, nor the regulators. CMIs also look for increasing revenues and profits in absolute real terms. Regulators refrain from over promoting integration and consolidation due to competition issues. Especially in European context, big mergers that would end up with pan European monopolies are prohibited. For example, in 2016 merger proposal of DBG and LSEG rejected by the competition authority of EU. CMIs uses integration and diversification strategies to increase their revenues and net income as well as to increase cost efficiency and profitability.

5.6.2 Business Integration Models

Integration has altered effects with respect to market beneficial ownership type and perspective of time, short run or long run. Market beneficial owner type coincides with the distinction of emerging and developed markets. Therefore, in the context of this paper, non-beneficial owner markets are developed markets and beneficial owner markets are emerging markets. Developed markets are associated with fragmented surveillance, fast transaction processing and allowance of nominee concept. On the other side, emerging markets are associated with central oversight and accumulation of investor detail in centrally controlled infrastructures. This distinction of regulatory background also affects the possibilities of integration. Horizontal and multiway integrations are limited in emerging markets due to the protective regulatory framework. In these markets, country level restructurings are predominant. On the contrary, developed markets are open to global mergers in horizontal, vertical or multiway models.

Integration in any form increases use of scale economies and therefore long run cost efficiency. Integration in any form does not reduce costs in the short run significantly; integration model matters. No-integration also does not alter profitability significantly.

Horizontally integrated exchanges have lower average costs compared to non integrated or vertically integrated exchanges (both exchange-CCP or silo model). The results partially support Köppl and Monnet (2007) who argue horizontal integration achieves competition of a few, hence efficient use of resources. Cost reduction effects of horizontal integration is not significantly different from multiway integration. Results provide support for our third hypothesis that horizontal integration increases short run cost efficiency.. Horizontal integration increases the profitability in general; this result cannot be confirmed for exchanges. Therefore, we can attribute the profitability due to horizontal integration to post trade CMIs, CCPs and CSDs. The results partially support our sixth hypothesis that integration is profitable.

Vertical integration all value chain in silo model increases contemporaneous overall cost more than any other integration and no integration. Nevertheless, it significantly increases utilization of scale economies and long run cost efficiency compared to horizontal and exchange CCP vertical integrations. Short run effects of vertical integration, either in the form of exchange CCP integration or silo model, are insignificant. Therefore our third hypothesis is supported for long run efficiency. Short run efficiency reduction could not be verified. Our results for short run efficiency provide partial support for the argument that vertical integration of exchanges is a barrier against efficient exchange consolidation (Köppl and Monnet, 2007). On the other side, our findings on long run cost saving potential of vertical integration provide support for the prevention of double margining and reduction in unit cost due to vertical integration (Tapking and Yang, 2006). Exchange and CCP integration is more cost efficient than no integration. However, cost reduction effect of exchange CCP integration (Pirrong, 2008) compared to other forms of integration could not be verified. Vertical integration has no significant effect on profitability. There is no evidence for market power due to vertical integration. Therefore, our sixth hypothesis is not supported for vertical integration. The results deos not support Sharper (2012) and Li and Marinč (2016).

Multiway integration increases use of scale economies and long run cost efficiency significantly. It reduces average costs in developed markets as well. The results support our fourth hypothesis that multiway integration increases short run and long run cost efficiency. Recent global mergers and merger attempts that result or would result in multiway integration is supported by the results. Tapking and Young (2006) handle multiway integration in their two-country theoretical model and argue vertical integration in one country and horizontal integration of post-trade services in the other has the highest economic welfare. Our results are supportive. On the profitability side, multiway integration increases the profitability significantly. These results reveal that cost gains due to multiway integration are partly captured by the CMIs themselves as profits.

In emerging markets due to regulatory background, horizontal and multiway integrations are not applicable. Vertical integration and product differentiation are the only tools to increase scale and scope. Our data reveals that almost all entities in emerging markets already used the two opportunities of integration. Tadawul is the only undifferentiated exchange, as the derivatives market is not yet available in Saudi market. NSDL of India is the only horizontally integrated CSD in emerging markets. We should also note the India has the lowest overall cost as well as average cost in emerging markets. Positive relation with entity size with short-run and long-run cost efficiency in emerging markets points need for more integration in these markets in order to increase cost efficiency. In emerging markets increased size is also associated with pricing power. This indicates that CMIs have excess market power in these markets. Regulators should consider integration and competition together.

5.6.3 Diversification aspects and economies of scope

Our diversification variables relate to economies of scope, as they indicate expansion of CMI businesses to other related areas.

Asset class differentiation is about providing trading services for multiple asset classes. A most simple example is an exchange with stock market, which increases its scope to derivatives market trading. Asset class differentiation is possible both in emerging and developed markets. Differentiation decreases average costs and increases utilization of long run cost saving potential due to scale for exchanges. The effect is not generalizable to all CMIs as differentiation variable does not apply to the CSDs. All CSDs are undifferentiated as they provide infrastructure for securities only. Therefore, we can conclude that the effects of differentiation is inconclusive for the CMI industry as a whole. However, differentiation has positive effects on short and long run cost efficiency for exchanges. For CSDs, ICSD diversification can be interpreted as economies of scope. Within the ICSD structure, CSDs provide additional services such as banking and cross border global settlement. However, ICSDs have higher average cost and utilize scale economies less. Therefore, ICSDs are less efficient compared to other CMIs in general. However, we should note that ICSD business model is very complex. The ICSD business specific complexity could not be reflected to our models as we try to provide a global picture for all types of CMIs. Still, our results support the recent developments in ICSD business. LSEG and global custodian bank 'Bank of New York Mellon' (BONY Mellon) established their own ICSDs 'globesettle' and 'BONY Mellon CSD' in Luxemburg in 2015. Their objective is to compete with the existing ICSDs; Euroclear and Clearstream. They got official approvals; however, these ICSDs has not launched operationally due to high costs. Hence, our fifth hypothesis that scope economies are available is partially supported by the results. Scope economies are available for exchanges.

Effects of providing data and information services on cost efficiency could not be analyzed due to measurement limitations. We cannot provide a proper output measure for the data service that fits with our settings. Therefore, for the cost analysis costs that related to data and information services business lines are excluded.

Profitability effect of product differentiation is insignificant in exchanges. The results encounter Serifsoy (2007) and Sharper (2012) who argue that exchanges (in developed markets) goes for product differentiation with motivation to increase profits rather than cut costs. However, the effect is significantly positive for all CMI data. This is mainly shows that differentiation make sense if we compare exchanges and other CMIs together. Exchanges are more profitable than other CMIs. Almost all of them already utilized profitability due to differentiation. Therefore if analyze exchanges only, no significant effect is seen. Differentiation is a matured strategy that is already consumed by all exchanges.

Diversification to data and information services reduces profitability significantly. This type of diversification is quite new (LSEG 2014 and ICE 2016); therefore, it is early to see a concluding effect. Still, this diversification clearly increases revenue generation capability.

CME Group and CBOE are the two biggest derivatives exchanges that are specialized in derivatives trading and clearing solely. Although there are estimations that derivatives exchanges are more profitable in the literature (Lees, 2012), we could not find any evidence of profitability of these exchanges. However, these special derivatives exchanges (we should also include DBG's Eurex of Europe and ICE) have global reach, their size and scale are among the biggest. Therefore, their profits are much higher in dollar terms (Figure 5.3), not profitability ratios.

5.6.4 Geographical regions

US is the most cost efficient region. Long-run cost efficiency is evident when securities and derivatives scale elasticities are analyzed separately. Results are in line with literature. DTCC is the post trade institution with highest utilization of scale economies in securities transactions. This result is in line with Li and Marinč (2016) as well as Malkamäki and Tarkka (2006), as they also found that US post trade CMIs are the most efficient CMIs. In the short run, the efficiency of US and Asia Pacific regions are similar.

Asia Pacific region also provide low cost infrastructure environment in the short run together with US. Long run effects are inconclusive. Asia Pacific emerging markets are significantly less profitable than other emerging markets including India. Hence, we can argue that Asia Pacific emerging markets outperforms other emerging markets in all types of efficiency. These markets are Korea and Singapore. We should also note that these markets are among biggest emerging markets (in terms of entity size and output scale).

In Europe no costs efficiency aspect is found significant. Results indicate that Europe is less cost effective compared to the US. Results support efforts in European region for more integration for cost efficiency. However, the results are partial. No significant difference is available in the profitability of the CMIs in the US and Europe. Our significant results address the cost side only. Policy implications should consider both costs and competitiveness.

India has a special case. It has the lowest total costs. Average costs are significantly lower than other emerging markets. We believe that low-cost high-quality IT human resources in the country play a key role in these results. India is significantly profitable than other emerging markets. It is the only market, in which two vertically integrated CMI groups are operating. In no other market or region, two vertically integrated CMIs that operates under same jurisdiction. Results reveal that availability of multiple CMIs does not guarantee efficient price allocation. The CMIs might still preserve market power. This is mainly due to the fact that the two exchanges of India BSE and NSE divides the market segments in terms of investor appetite and product type. Therefore, they cannot effectively compete in pricing. Another obvious reason of higher profitability in India is the fact that the costs are extremely low. These exchanges benefit from low cost structure. Among all other integration models, highest economic welfare could be achieved by vertical silo model if the vertical silos are open to competition to other vertical silos (Köppl and Monnet, 2007; Kauko, 2004). Our results support that costs are lowered; however, we cannot confirm overall welfare effect. In addition, feasibility of two competing vertical CMI model requires very high output levels under one jurisdiction, where issuers have complete mobility in choosing the CMI to issue and list their securities. In reality, issuers are restricted by the jurisdictions and regulatory requirements, dominant market share and liquidity provision of a CMI in a market.

5.6.5 Time trend, entity size and type

Our empirical findings support that total costs are increasing over time. Increasing costs over time can be explained by additional costs of new functions or services provided by CMIs. Nevertheless, technical inefficiency has low significance level, still reduces over time significantly. These are in line with unit cost efficiency gains in the short run and long run with time. Median and mean average cost, use of scale economies and net profit ratio over time are presented in Figure 5.12. Graphs are in line with the significant time variables in our models (Tables 5.10, 5.22 and 5.28).

Time is insignificant for emerging markets. Technical improvement over time does not reduce costs in these markets. In developed markets, technological improvements over time reduces costs in the short and long run. The effect mainly stems from securities markets. For profitability, there is no significant time trend.

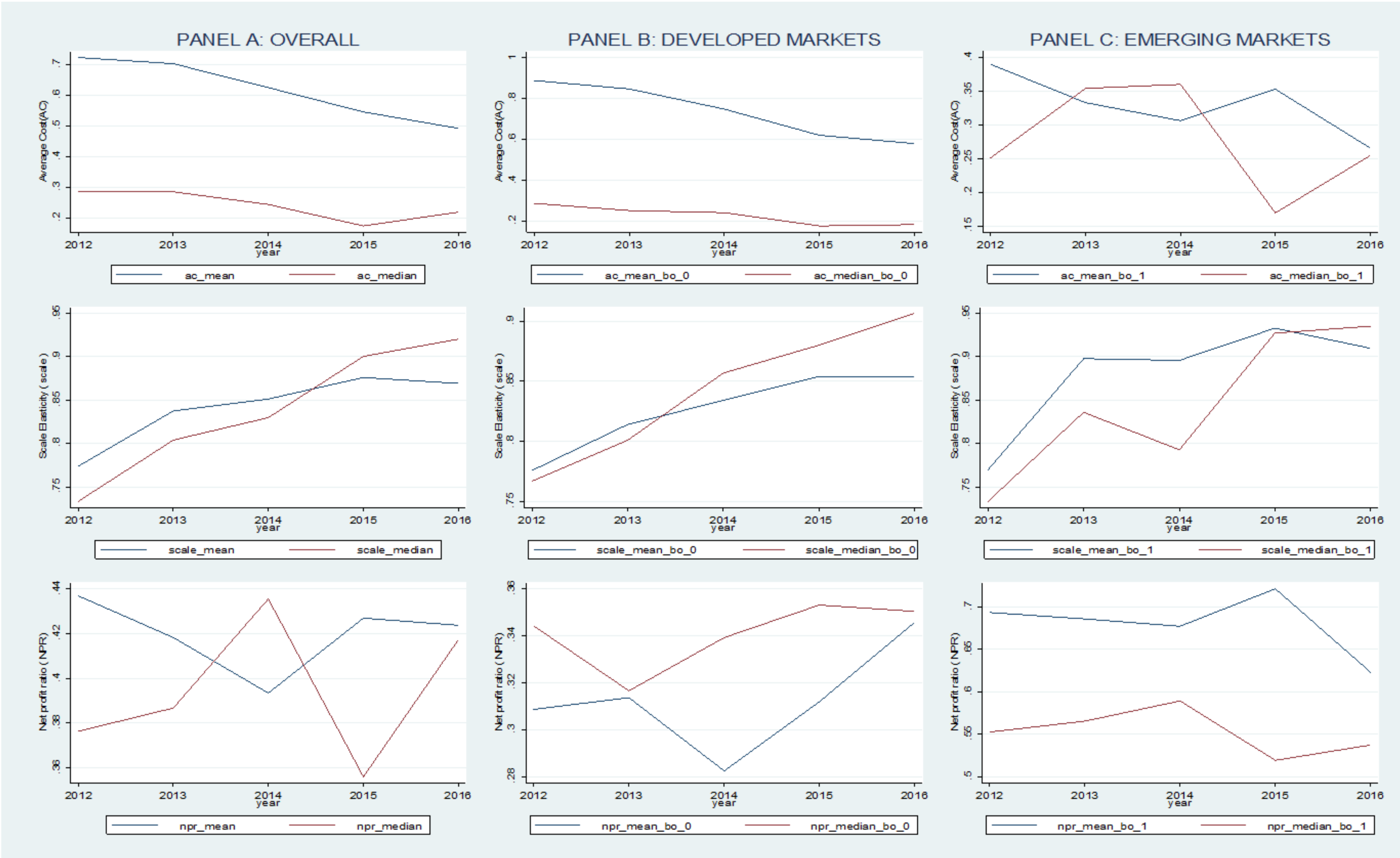


Figure 5.14 : Time trend summary.

Mean average cost decrease and utilization of cost savings potential due to scale increases over time. Although our period of 5 years is short to prove the long-run effects, decline in average costs and increase in gains from economies of scale over time is evident. The decomposition of time effect per developed (bo=0) and emerging markets (bo=1) are also provided. As seen from the graphs, decreasing average cost and increasing gains form scale economies is evident in developed markets. The effect is not clear in emerging markets though. In line with the graphs, the time coefficients in regressions of average cost and scale for emerging markets are insignificant.

The graph indications are consistent with significant time coefficients in our regressions in general and for developed markets. In general, our analysis puts forward increased cost efficiency due to utilization of scale economies and better use of technology over time, following the general literature about firm production function. As utilization of scale economies continuously increase and average costs continuously decrease, we contend that the industry overall exhibits the production function of natural monopolies due to network economies. The findings are in line with Knieps (2006) since our production function indicates network economies and with Malkamäki and Tarkka (2006) and Van Cayseele and Wuyts (2007) who show decreasing costs over time. Entity size is significant for gains from economies of scale in emerging markets. As these markets are associated with low output levels and lack of scale economies in general, increasing the company size, increases output scale and enhances gains from scale economies. However, most developed markets are already above the threshold. Increased size reduces short run cost efficiency and insignificant for long run cost efficiency in developed markets. Results signals that increasing size might make organizations more complex in developed markets.

Exchanges have higher total costs. This is because exchanges usually grow in size with integrations and differentiation. Entity type is insignificant for short run cost efficiency in developed markets. Positive sign in CSDs in emerging markets for short and long run efficiency is a special case for India, therefore not conclusive. Cost of ICSDs are higher than other CMIs. As ICSDs provide cross border settlement, bank correspondence and various additional downstream custody services, the scope and nature of business is different from other CSDs. The average cost comparison of CSDs is provided in Figure 5.9 (Panel B). The two full scope ICSDs Euroclear and Clearstream has comparably highest costs among CSDs operating in developed markets. These results shed light on the complicated structure of cross border settlement, as it requires account links and operational capability with multiple jurisdictions, currencies and market requirements. This result is in line with Li and Marinč (2016) as well as Malkamäki and Tarkka (2006), as their studies also reveals special case of ICSDs.

5.7 Conclusion

Especially, in the aftermath of global economic crisis, transaction costs have become a primary focus for regulators and investors. However, a comprehensive study about cost and pricing efficiencies in short and long run under certain business integration models remains missing in the literature. We try to fill in this gap by exhaustively analyzing all the CMIs (trade and post-trade infrastructures together) globally. To the best of knowledge, within the integration framework, our study is first for considering both trade and post-trade infrastructures worldwide.

We analyze the effect of business integration model and diversification aspects on total cost, average cost and scale elasticity. Average cost shows the concurrent nature of costs. Therefore, we regard these costs short run costs. On the other side, scale elasticity shows the utilization of scale economies, therefore we take this as indicator for utilization of long run cost saving potential. Our analysis is unique in that we evaluate both short-term and long-term effects. In addition, we consider price efficiency together with cost efficiency. We embrace different theories in CMI integration literature. Moreover, we include in our analysis all types of institutions in capital market infrastructure value chain. Previous studies focus on exchanges or CSDs only. Another novelty of our study is that we included emerging markets in our dataset. Previous literature is mostly based on the developed markets. We extend the data to emerging market and see different effects in these markets. Hence, our results yield implications for policy makers and CMIs in developed and emerging markets, from both short- and long-run perspectives, for both trade and post trade infrastructures. In this study, our focus is the cost and pricing efficiency, not the absolute costs and profits. Further studies on absolute profits, and per unit revenues would add value to the literature regarding the pricing power and competitiveness in this industry. This would complement our results regarding monopoly and network effects in the industry.

In capital market infrastructure industry, US region provides highest cost efficiency, Asia Pacific follows. Europe has no significant cost efficiency aspect, although it has the largest scale after US. There is room for more integration in Europe to increase the cost efficiency. However, issues for competition should also be considered. India has a special case of low-cost structure.

In emerging markets, differentiation and vertical integration attempts can be explained by the effect of entity size in these markets. Although most emerging markets are organized as differentiated vertical silos in order the utilize cost efficiencies, current level of integration is insufficient. There is potential cost gains from further integrations. Our policy recommendation for emerging markets would be opening ways for integration at regional or global level.

Any form of integration reduces costs in the long-run. Vertical and multiway integrations increase cost efficiency even more in in the long-run. Multiway integration has further short run advantages. Multiway integration also increases profitability. Our results explain merger talks among global sector leaders. Multiway integration allows organization to use most efficient technology, benefit more from network economies, consequently increase profits. Securities markets are more mature and their long-run cost saving potential is utilized more compared to the derivatives markets. Diversification in the form of asset class differentiation reduces costs both in the short and in long run for the exchanges. It also increases profitability. Diversification in terms of data and information services increases revenue generation; meanwhile its effect on profitability is negative. These services constitute a new business area for CMIs; still, their ability to increase CMI profitability is not yet evident.

Efficiency gains over time is significant and positive in developed markets. The cost structure points out to natural monopoly and network economies. The industry is far from long-run equilibrium.

6. CONCLUSION

In this dissertation, our objective is to provide a comprehensive study of business integration and product diversification aspects in the CMI industry. We combine industry overview with economic literature and empirical analysis.

CMIs are exchanges, CCPs and CSDs. Exchanges provide trade execution, CCPs clearing and CSDs settlement services for the secondary markets. Exchanges also provide listing and CSDs depository functions for the primary markets. Business integration models are horizontal integration across market places or vertical integration in the value chain. Multiway integration embraces both horizontal and vertical integrations. Integration is the consolidation of management and organization in one reporting entity. Other linkage strategies that assures market integrity or competition are also available.

The current snapshot of the world CMIs reveals that most horizontal and multiway integrations take place in developed markets, especially in the US and Europe. Emerging markets are characterized with vertical integration in the value chain. Regulatory changes and market beneficial ownership types affect the integration opportunities among the CMIs. In emerging markets, integration and product diversification strategies are mostly limited within the national borders. In developed markets, horizontal integrations among market places, or multiway integrations and product diversifications took place through mergers and acquisitions. Merger events are classified into waves which shape integration and diversification landscape. We believe that our classification and analysis provide a comprehensive global classification for all types of CMIs. We believe that our world map of CMIs and merger classification are quick and effective tools to understand the industry.

We also provide a comprehensive economic literature on the market design, efficiency measurement, integration and product diversification in the industry. We combine various aspects of integration and product diversification available in the literature. Cost efficiency is about achieving highest productivity with minimum wasted expense. It focuses on the production function. Economic efficiency (or price allocation efficiency) measures the ability of the market to have competitive pricing. It outlines profitability.

Our empirical research on the cost and pricing efficiency constructs the critical part of the dissertation. We analyze 34 CMIs from 22 CPMI countries. Different data sources are cross checked for compatibility. The small number of observations is a limitation in our analysis. Number of CMIs are limited due to the nature of their business. Data period is also short. The data period should either be as long as 20 to 30 years so that macroeconomic factors can better be included in the model. However financial reports of CMIs are published seven to ten years back in timeline. Therefore we reduced the data period to five years, where macroeconomic and exogenous factors are similar.

The main difficulty of the empirical analysis is establishing cost efficiency measures. Our estimation methods bring about new perspective to efficiency analysis in CMIs. All previous empirical research aggregate number of transactions in one output. Number of derivatives contracts are in millions whereas number of securities transactions are in thousands. Therefore in number of derivatives contracts processed always overrides number of securities transactions, which potentially leads to biased results. In order to be able to incorporate both outputs in the model we include them in two separate output types. As our focus is to assess industrial performance of the CMIs as transaction processing factories, we take number not dollar volume of transactions. Therefore, we omit measurements that focus on market performance such as turnover or market capitalization. We regard CMIs as factories and count the number of transactions or contracts they process. For simplicity, we assume trade execution, clearing and settlement as equally weighted transactions. We use unnetted pre-settlement figures for settlement to assure compatibility. We differentiate securities and derivatives output levels as securities are indicated in number of transactions processed while derivatives are indicated in number of derivatives contracts processed.

We employ stochastic frontier regression to obtain the cost output elasticities, which is widely used as indicator of cost savings due to scale economies. This is also a major proxy for long-run cost saving ability. We take the average cost as indicator of short-run costs. Our attempt is the first to model long- and short-run cost efficiencies together. Consequently, our results embrace different angles in the literature. To the best of our knowledge, our study is unique in that we distinguish short and long run perspectives.

We measure average cost by applying the expansion path between the two output types. We use market level aggregated data to construct the expansion path function between the two output types. We then apply the function to CMIs' outputs. By doing so, we reach a hypothetical average transaction cost per securities equivalent transaction. To the best of our knowledge, we are first to calculate average cost in two output set-up in the CMI literature. We believe that using expansion path in order to reduce output types to one is among the novelties of our study. This is our solution to summing up number of securities transactions with number of derivatives contracts that would end up with biased results. Still, our method has limitations. We assumed a linear path between the two output types. Future research about the form of the relationship between securities and derivatives markets outputs would contribute to efficiency analysis in this industry.

In our analysis, we include all types of CMIs. As diversification and integration concern consolidation of different CMI types (for example exchanges with CCPs or CCPs with CSD, etc.), handling jointly these entities is important. We provide implications for emerging as well as developed markets. Our research is also first in the literature to include CMIs of Turkey within a global comparison.

Our results indicate that business integration reduces costs in the long run. In silo model vertical integration of whole value chain or multiway integration, long-run cost saving is higher. Securities markets are more mature and their long-run cost saving potential is utilized more compared to the derivatives markets. Diversification in the form of asset class differentiation reduces costs both in the short and in long run for the exchanges. It also increases profitability. Diversification in terms of data and information services increases revenue generation; meanwhile its effect on profitability is negative. These services constitute a new business area for CMIs; still, their ability to increase CMI profitability is not yet evident. For emerging markets, size matters. Further consolidations would increase cost efficiency as well as profitability. CMIs industry in the US market is associated with highest cost efficiency. More integration is needed in Europe for cost efficiency. However, policy makers also consider competition aspects against full consolidation. India is a special case of lowest total and average cost. This is mainly due to the surplus of qualified IT human resources in the country. Indian CMIs enjoy pricing power and utilize a part of the gains from the cost savings as profits. Entity size matters for the emerging world as for both cost efficiency and profitability. In case emerging market CMIs achieve to integrate more, they will reduce the costs and consequently benefit from increased profits. Technological improvements over time have reduced costs significantly in developed markets.

We evaluate cost and pricing efficiency in the same manner. This could also be limitation. We use our cost efficiency set up in evaluating profitability. However, different factors such as ownership structure, types of shareholders, level of market fragmentation could affect the profit motives and profitability of CMIs. Further studies that focus on different aspects of profitability could complement our results.

An empirical study on the network effects in the industry would contribute to the literature, although it remains beyond the scope of this dissertation. In this study, we profoundly analyze scale and scope economies. Yet, network effects are very important in understanding the global competition of the industry. Especially, the introduction of distributed ledger technologies, which is in early stages now, would make the competition for network much harder. Therefore, further investigation on the network competition would significantly add to the CMI literature.

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APPENDICES

APPENDIX A: Diagnostic tests for total cost model regression.
APPENDIX B: Diagnostic tests for average cost (AC) model regression.
APPENDIX C: Diagnostic tests for scale elasticity model regression.
APPENDIX D: Diagnostic tests for profitability (NPR) model regression.

APPENDIX A

Table A.1: Comparison frontier and random effects GLS model coefficients**.**

Variable	Frontier model estimated coefficients for Ln (TC)	Random Effects model estimated coefficients for Ln (TC)
qseclsq	.06161675***	.04822729***
qdlsq	.06058913***	.07503231**
qsecl	-1.4129937*	-1.6543008*
qdl	-1.7617026***	-1.2099243***
qsecdl	0.00691224	-0.01718739
plsq	.30873216**	.3098325*
pl	-6.7954283**	-6.7170718*
plsec	0.08789411	0.12453004
pld	.12031115***	.05866828**
gdpl	.60969633***	.62384493***
time	0.04047083	-.03957836*
bo	0.30713929	0.00176375
exch	1.3877509***	1.9361333***
csd	0.44555602	.62922825**
icsd	2.0841655***	2.0504944***
diff	0.82946706	1.599501**
horiz	-0.09893276	0.10760348
vert_exccp	-0.01762826	0.06248994
vert_silo	.43493561*	0.38522904
multi	-0.35461739	-0.16555573
reg_us	-0.11966163	-0.38881958
reg_eurp	0.43937821	0.10335808
reg_ap	0.13108584	0.20407376
reg_india	-2.0467041***	-1.6949684**
_cons	23.131754	22.205127
lnsigma2	-1.3289861**	
ilgtgamma	1.8801309***	
mu	.43081388*	
eta	.12086295***	
chi2	1330.5814	1768.15
df		
N	161	161
aic	88.838295	.
bic	178.19902	.
rank	29	25

legend: * p<.1; ** p<.05; *** p<.01

Table A.2 : Hausman test for fixed or random effects.

```
. hausman fixed random
                ---- Coefficients ----
             |      (b)          (B)            (b-B)     sqrt(diag(V_b-V_B))
             |     fixed        random       Difference          S.E.
-------------+----------------------------------------------------------------
     qseclsq |    .0803582     .0482273        .0321309          .02601
       qdlsq |    .0418536     .0750323       -.0331787        .0261472
       qsecl |   -2.009923    -1.654301       -.3556218        .3968524
         qdl |   -.4960079    -1.209924        .7139164        .3281445
      qsecdl |    .0125477    -.0171874        .0297351        .0222019
        plsq |    .8996984     .3098325        .5898659        .1350983
          pl |   -17.53377    -6.717072       -10.81669        3.359837
       plsec |    .1070221       .12453       -.017508        .0399838
         pld |   -.0104105     .0586683       -.0690788        .0519701
        gdpl |    2.964457     .6238449        2.340612        2.258109
        time |   -.1372346    -.0395784       -.0976563        .0332449
        diff |    1.135951     1.599501       -.4635502        .6622952
  vert_exccp |   -.0223206     .0624899       -.0848105        .4215734
   vert_silo |    .4706541      .385229        .0854251        .3599034
       multi |   -.5683777    -.1655557       -.4028219        .4518668
------------------------------------------------------------------------------
            b = consistent under Ho and Ha; obtained from xtreg
            B = inconsistent under Ha, efficient under Ho; obtained from xtreg
    Test:  Ho:  difference in coefficients not systematic
                 chi2(15) = (b-B)'[(V_b-V_B)^(-1)](b-B)
                          =       22.46
                Prob>chi2 =      0.0963    (V_b-V_B is not positive definite)
```

Table A.3 : Test for entity specific effects.

```
Breusch and Pagan Lagrangian multiplier test for random effects
        tcl[entno,t] = Xb + u[entno] + e[entno,t]
        Estimated results:
                         |       Var     sd = sqrt(Var)
                ---------+-----------------------------
                     tcl |   1.828836       1.352345
                       e |   .0387061       .1967386
                       u |   .1230014       .3507156
        Test:   Var(u) = 0
                             chibar2(01) =    30.64
                          Prob > chibar2 =   0.0000
```

Table A.4 : Tests for serial correlation.

```
. xtserial tcl qseclsq qdlsq qsecl  qdl  qsecdl plsq pl plsec pld gdpl time bo exch csd
icsd diff horiz vert_exccp vert_silo multi reg_us reg_eurp reg_ap reg_india

Wooldridge test for autocorrelation in panel data
H0: no first-order autocorrelation
    F(  1,      31) =      0.348
           Prob > F =      0.5594

. xtserial tcl qsecl  qdl  pl gdpl time bo exch csd icsd diff horiz vert_exccp vert_silo
multi reg_us reg_eurp reg_ap reg_india

Wooldridge test for autocorrelation in panel data
H0: no first-order autocorrelation
    F(  1,      31) =      2.275
```

Table A.5 : Unit root test for variables.

```
. xtunitroot hadri tcl, trend robust
Hadri LM test for tcl
-----------------------
Ho: All panels are stationary              Number of panels  =     31
Ha: Some panels contain unit roots         Number of periods =      5
Time trend:         Included               Asymptotics: T, N -> Infinity
Heteroskedasticity: Robust                                  sequentially
LR variance:        (not used)
------------------------------------------------------------------------------
                    Statistic      p-value
------------------------------------------------------------------------------
 z                   -0.1549       0.5615
------------------------------------------------------------------------------

. xtunitroot hadri qsecl, trend robust
Hadri LM test for qsecl
-------------------------
Ho: All panels are stationary              Number of panels  =     31
Ha: Some panels contain unit roots         Number of periods =      5
Time trend:         Included               Asymptotics: T, N -> Infinity
Heteroskedasticity: Robust                                  sequentially
LR variance:        (not used)
------------------------------------------------------------------------------
                    Statistic      p-value
------------------------------------------------------------------------------
 z                   -2.3848       0.9915
------------------------------------------------------------------------------

. xtunitroot hadri qdl, trend robust
Hadri LM test for qdl
-----------------------
Ho: All panels are stationary              Number of panels  =     31
Ha: Some panels contain unit roots         Number of periods =      5
Time trend:         Included               Asymptotics: T, N -> Infinity
Heteroskedasticity: Robust                                  sequentially
LR variance:        (not used)
------------------------------------------------------------------------------
                    Statistic      p-value
------------------------------------------------------------------------------
 z                   -2.9951       0.9986
------------------------------------------------------------------------------

. xtunitroot hadri pl, trend robust
Hadri LM test for pl
----------------------
Ho: All panels are stationary              Number of panels  =     31
Ha: Some panels contain unit roots         Number of periods =      5
Time trend:         Included               Asymptotics: T, N -> Infinity
Heteroskedasticity: Robust                                  sequentially
LR variance:        (not used)
------------------------------------------------------------------------------
                    Statistic      p-value
------------------------------------------------------------------------------
 z                   -0.0012       0.5005
------------------------------------------------------------------------------

. xtunitroot hadri gdpl, trend robust
Hadri LM test for gdpl
------------------------
Ho: All panels are stationary              Number of panels  =     31
Ha: Some panels contain unit roots         Number of periods =      5
Time trend:         Included               Asymptotics: T, N -> Infinity
Heteroskedasticity: Robust                                  sequentially
LR variance:        (not used)
------------------------------------------------------------------------------
                    Statistic      p-value
------------------------------------------------------------------------------
 z                   -0.0047       0.5019
------------------------------------------------------------------------------
```

Table A.6 : Likelihood-ratio tests for joint significance of integration/ diversification, region and entity type variables.

```
. lrtest full wo_BIM_DIV
Likelihood-ratio test                                  LR chi2(7)  =     38.58
(Assumption: wo_BIM_DIV nested in full)                Prob > chi2 =    0.0000

. lrtest full wo_BIM
Likelihood-ratio test                                  LR chi2(4)  =     12.14
(Assumption: wo_BIM nested in full)                    Prob > chi2 =    0.0163


. lrtest full wo_DIV
Likelihood-ratio test                                  LR chi2(2)  =     22.57
(Assumption: wo_DIV nested in full)                    Prob > chi2 =    0.0000

. lrtest full wo_REG
Likelihood-ratio test                                  LR chi2(4)  =     11.39
(Assumption: wo_REG nested in full)                    Prob > chi2 =    0.0225

. lrtest full wo_TYPE
Likelihood-ratio test                                  LR chi2(2)  =     15.95
(Assumption: wo_TYPE nested in full)                   Prob > chi2 =    0.0003

. lrtest full wo_BO_TYPE
Likelihood-ratio test                                  LR chi2(4)  =     35.51
(Assumption: wo_BO_TYPE nested in full)                Prob > chi2 =    0.0000
```

Full model is the main model presented in Table 5.3. In “wo_BIM_DIV” model variables related to business integration and diversification are excluded (horiz, vert_exccp, vert_silo, multi, diff, ICSD). In “wo_BIM” model variables related to business integration are excluded (horiz, vert_exccp, vert_silo, multi). In “wo_DIV” model variables related to diversification are excluded (diff, ICSD). In “wo_REG” model variables related to region are excluded (reg_us, reg_eurp, reg_ap, reg_india). In “wo_TYPE” model variables related to entity type are excluded (exch, CSD). In “wo_BO_TYPE” model variables related to market beneficial ownership and entity type are excluded (bo, exch, CSD).

Table A.7 : Tests for equality of coefficients.

```
. test reg_india=reg_us
 ( 1)  - [tcl]reg_us + [tcl]reg_india = 0
           chi2(  1) =    9.00
         Prob > chi2 =    0.0027
. test reg_india=reg_eurp
 ( 1)  - [tcl]reg_eurp + [tcl]reg_india = 0
           chi2(  1) =   13.61
         Prob > chi2 =    0.0002
. test reg_india=reg_ap
 ( 1)  - [tcl]reg_ap + [tcl]reg_india = 0
           chi2(  1) =   11.49
         Prob > chi2 =    0.0007
. test vert_silo=horiz
 ( 1)  - [tcl]horiz + [tcl]vert_silo = 0
           chi2(  1) =    4.29
         Prob > chi2 =    0.0383
. test vert_exccp=vert_silo
 ( 1)  [tcl]vert_exccp - [tcl]vert_silo = 0
          chi2(  1) =    6.86
         Prob > chi2 =    0.0088
. test vert_silo=multi
 ( 1)  [tcl]vert_silo - [tcl]multi = 0
           chi2(  1) =   12.16
         Prob > chi2 =    0.0005
```

Based on Ln TC model in Table 5.3.

Table A.8 : Including business integration variables individually to the Ln TC model in Table 5.3.

```
.xtfrontier tcl qseclsq qdlsq qsecl  qdl  qsecdl plsq pl plsec pld gdpl time bo exch csd icsd diff horiz
vert_exccp vert_silo multi reg_us reg_india,  tvd cost
Time-varying decay inefficiency model           Number of obs      =       161
Group variable: entno                           Number of groups   =        34
Time variable: year                             Obs per group:
                                                              min =         1
                                                              avg =       4.7
                                                              max =         5
                                                Wald chi2(22)      =   1500.03
Log likelihood  = -20.259373                    Prob > chi2        =    0.0000
```

tcl	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
qseclsq	.0222778	.0134295	1.66	0.097	-.0040435	.0485992
qdlsq	.0748533	.0152329	4.91	0.000	.0449974	.1047092
qsecl	-.3020192	.9714633	-0.31	0.756	-2.206052	1.602014
qdl	-.2977919	.2779548	-1.07	0.284	-.8425733	.2469894
qsecdl	-.0699383	.0137697	-5.08	0.000	-.0969264	-.0429503
plsq	.2234974	.1710349	1.31	0.191	-.111725	.5587197
pl	-4.580573	3.563349	-1.29	0.199	-11.56461	2.403463
plsec	.040004	.0949869	0.42	0.674	-.146167	.2261749
pld	-.0003174	.0222353	-0.01	0.989	-.0438978	.043263
gdpl	.6168028	.0921608	6.69	0.000	.4361709	.7974346
time	-.098962	.0212969	-4.65	0.000	-.1407032	-.0572208
bo	-.6930525	.1715893	-4.04	0.000	-1.029361	-.3567436
exch	2.29706	.1923458	11.94	0.000	1.920069	2.674051
csd	1.383382	.1916566	7.22	0.000	1.007742	1.759022
icsd	1.514197	.1823121	8.31	0.000	1.156872	1.871523
diff	1.691277	.3983384	4.25	0.000	.9105477	2.472006
horiz	-.361024	.2375331	-1.52	0.129	-.8265803	.1045323
vert_exccp	-.368622	.216499	-1.70	0.089	-.7929521	.0557082
vert_silo	.2737717	.1808936	1.51	0.130	-.0807733	.6283166
multi	-.1250973	.260463	-0.48	0.631	-.6355953	.3854008
reg_us	-1.260324	.3806656	-3.31	0.001	-2.006415	-.5142335
reg_india	-2.093272	.7713245	-2.71	0.007	-3.60504	-.581504
_cons	7.748011	18.16204	0.43	0.670	-27.84893	43.34495
/mu	-329.2844	3443.373	-0.10	0.924	-7078.172	6419.603
/eta	-.173328	.0480408	-3.61	0.000	-.2674862	-.0791699
/lnsigma2	5.193644	10.41873	0.50	0.618	-15.2267	25.61399
/ilgtgamma	8.306192	10.42302	0.80	0.426	-12.12255	28.73494
sigma2	180.1237	1876.661			2.44e-07	1.33e+11
gamma	.9997531	.002573			5.44e-06	1
sigma_u2	180.0792	1876.661			-3498.108	3858.267
sigma_v2	.0444765	.0061403			.0324416	.0565113

```
xtfrontier tcl qseclsq qdlsq qsecl  qdl  qsecdl plsq pl plsec pld gdpl time bo exch csd icsd diff horiz vert_exccp
vert_silo multi reg_eurp reg_india,  tvd cost
Time-varying decay inefficiency model           Number of obs      =       161
Group variable: entno                           Number of groups   =        34
Time variable: year                             Obs per group:
                                                              min =         1
                                                              avg =       4.7
                                                              max =         5
                                                Wald chi2(22)      =   1277.99
Log likelihood  = -15.749941                    Prob > chi2        =    0.0000
```

tcl	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
qseclsq	.0647213	.0123764	5.23	0.000	.040464	.0889785
qdlsq	.0534145	.0144548	3.70	0.000	.0250837	.0817453
qsecl	-1.472728	.8069272	-1.83	0.068	-3.054277	.1088198
qdl	-1.778065	.3447393	-5.16	0.000	-2.453741	-1.102388
qsecdl	.0119642	.0117501	1.02	0.309	-.0110656	.0349941
plsq	.2697456	.1444472	1.87	0.062	-.0133657	.5528569
pl	-6.015367	2.983319	-2.02	0.044	-11.86256	-.1681703
plsec	.0897963	.0750065	1.20	0.231	-.0572136	.2368062
pld	.1263934	.0297074	4.25	0.000	.0681681	.1846188
gdpl	.5625259	.0984986	5.71	0.000	.3694722	.7555796
time	.0436072	.0226585	1.92	0.054	-.0008027	.0880171
bo	.3538519	.1893693	1.87	0.062	-.017305	.7250089
exch	1.409214	.3094907	4.55	0.000	.8026232	2.015805
csd	.487116	.312253	1.56	0.119	-.1248887	1.099121
icsd	2.060134	.3570877	5.77	0.000	1.360255	2.760013
diff	.6375244	.4474169	1.42	0.154	-.2393966	1.514445
horiz	-.033566	.2663256	-0.13	0.900	-.5555546	.4884225
vert_exccp	.0355857	.235963	0.15	0.880	-.4268933	.4980647
vert_silo	.4670093	.2322488	2.01	0.044	.01181	.9222086
multi	-.3108775	.2439459	-1.27	0.203	-.7890026	.1672476
reg_eurp	.4576808	.2478393	1.85	0.065	-.0280753	.943437
reg_india	-1.951023	.5844512	-3.34	0.001	-3.096527	-.8055198
_cons	20.5881	15.40949	1.34	0.182	-9.613935	50.79014
/mu	.4495026	.2355015	1.91	0.056	-.012072	.9110771
/eta	.1191156	.0229564	5.19	0.000	.0741219	.1641093
/lnsigma2	-1.231213	.5340999	-2.31	0.021	-2.278029	-.1843961
/ilgtgamma	2.012851	.6587206	3.06	0.002	.7217819	3.303919
sigma2	.2919383	.1559242			.102486	.8316063
gamma	.8821397	.0684867			.6729993	.964563
sigma_u2	.2575304	.1570705			-.0503222	.565383
sigma_v2	.0344079	.004731			.0251354	.0436805

Table A.8 (continued) : Including business integration variables individually to the Ln TC model in Table 5.3.

```
. xtfrontier tcl qseclsq qdlsq qsecl  qdl  qsecdl plsq pl plsec pld gdpl time bo exch csd icsd
diff horiz vert_exccp vert_silo multi reg_ap reg_india,  tvd cost
Time-varying decay inefficiency model           Number of obs      =       161
Group variable: entno                           Number of groups   =        34
Time variable: year                             Obs per group:
                                                            min =         1
                                                            avg =       4.7
                                                            max =         5
                                                Wald chi2(22)      =    993.33
Log likelihood  =  -17.43308                    Prob > chi2        =    0.0000
------------------------------------------------------------------------------
         tcl |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     qseclsq |   .0595608   .0141089     4.22   0.000     .0319079    .0872137
       qdlsq |   .0541474     .01667     3.25   0.001     .0214749      .08682
       qsecl |  -1.339159   .8243605    -1.62   0.104    -2.954876    .2765583
         qdl |  -1.599078    .351202    -4.55   0.000    -2.287421   -.9107343
      qsecdl |   .0072712   .0133512     0.54   0.586    -.0188967    .0334392
        plsq |   .2721198   .1532075     1.78   0.076    -.0281613    .5724009
          pl |  -5.895888   3.154558    -1.87   0.062    -12.07871    .2869315
       plsec |    .083681   .0771883     1.08   0.278    -.0676054    .2349673
         pld |   .1092065    .030486     3.58   0.000      .049455     .168958
        gdpl |   .5192431   .1074302     4.83   0.000     .3086839    .7298023
        time |    .039015    .024569     1.59   0.112    -.0091394    .0871695
          bo |   .2084741   .1864401     1.12   0.263    -.1569417    .5738899
        exch |   1.345433   .3856112     3.49   0.000     .5896487    2.101217
         csd |   .2899805   .3423825     0.85   0.397    -.3810769    .9610379
        icsd |   2.397447   .3434391     6.98   0.000     1.724319    3.070575
        diff |   .7687548   .5024955     1.53   0.126    -.2161182    1.753628
       horiz |   .0045922   .3305427     0.01   0.989    -.6432595    .6524439
  vert_exccp |   -.022267   .2771792    -0.08   0.936    -.5655282    .5209943
   vert_silo |   .3566399   .2573951     1.39   0.166    -.1478452     .861125
       multi |  -.3185383   .2890222    -1.10   0.270    -.8850113    .2479348
      reg_ap |   .0551996    .236733     0.23   0.816    -.4087885    .5191878
   reg_india |  -1.708299   .6075363    -2.81   0.005    -2.899049   -.5175501
       _cons |   20.38124   15.84001     1.29   0.198    -10.66462    51.42709
-------------+----------------------------------------------------------------
         /mu |   .5195811   .2222989     2.34   0.019     .0838833    .9552789
        /eta |   .1106708   .0247229     4.48   0.000     .0622148    .1591267
   /lnsigma2 |  -1.389787   .5247193    -2.65   0.008    -2.418218   -.3613563
  /ilgtgamma |   1.772291   .6764613     2.62   0.009     .4464509    3.098131
-------------+----------------------------------------------------------------
      sigma2 |   .2491283   .1307224                      .0890802    .6967307
       gamma |   .8547423    .083988                      .6097951    .9568156
    sigma_u2 |   .2129405   .1321602                     -.0460887    .4719696
    sigma_v2 |   .0361878   .0051128                      .0261669    .0462087
------------------------------------------------------------------------------
```

APPENDIX B

Table B.1 : Test for fixed or random effects for average cost regression.

```
Hausman test for fixed or random effects
                 ---- Coefficients ----
             |      (b)          (B)            (b-B)     sqrt(diag(V_b-V_B))
             |     fixed        random       Difference          S.E.
-------------+----------------------------------------------------------------
        diff |    .1071131    -.3637991        .4709121        .1875564
       indep |    1.271215     .4515588         .819656        .3207682
   vert_silo |    .2052779     .0864854        .1187925        .1774975
       multi |   -.3451647     -.212975       -.1321897        .1470521
         tal |      .11458     .0648569        .0497231        .0228033
        time |   -.0749547    -.0664923       -.0084623         .001757
------------------------------------------------------------------------------
            b = consistent under Ho and Ha; obtained from xtreg
            B = inconsistent under Ha, efficient under Ho; obtained from xtreg
    Test:  Ho:  difference in coefficients not systematic
                  chi2(6) = (b-B)'[(V_b-V_B)^(-1)](b-B)
                          =       16.21
                Prob>chi2 =      0.0127 (V_b-V_B is not positive definite)
```

Table B.2 : Test for entity specific random effects for average regression.

```
Breusch and Pagan Lagrangian multiplier test for random effects
        ac[entno,t] = Xb + u[entno] + e[entno,t]
        Estimated results:
                         |       Var     sd = sqrt(Var)
                      ac |   1.127559       1.061866
                       e |     .07424       .2724702
                       u |   .5115644       .7152373
----------------------------------------------------------------------
        Test:   Var(u) = 0
        chibar2(01) =   174.44    Prob > chibar2 =   0.0000
```

Table B.3 : Tests for cross sectional dependence .

```
Frees' test of cross sectional independence =     8.742
  Critical values from Frees' Q distribution
                      alpha = 0.10 :   0.5822
                      alpha = 0.05 :   0.8391
                      alpha = 0.01 :   1.4211
Average absolute value of the off-diagonal elements =     0.710
 ---------------------------------------------------------------------
Pesaran's test of cross sectional independence =     5.915, Pr = 0.0000
Average absolute value of the off-diagonal elements =     0.637
---------------------------------------------------------------------
Friedman's test of cross sectional independence =    16.238, Pr = 0.9864
Average absolute value of the off-diagonal elements =     0.710
```

Table B.4 : Tests for serial correlation for average cost and size variables.

```
Wooldridge test for autocorrelation in panel data
H0: no first-order autocorrelation
    F(  1,       31) =      4.384
           Prob > F =      0.0446
```

Table B.5 : Unit root test for average cost variable.

```
Hadri LM test for ac
Ho: All panels are stationary                 Number of panels  =     31
Ha: Some panels contain unit roots            Number of periods =      5

Time trend:         Included                  Asymptotics: T, N -> Infinity
Heteroskedasticity: Robust                                  sequentially
LR variance:        (not used)
------------------------------------------------------------------------------
                    Statistic      p-value
z                    0.0251        0.4900
```

Table B.6 : Test for region coefficients in average cost model in Table 5.5.

```
. test reg_us=reg_eurp
 ( 1)  reg_us - reg_eurp = 0
           chi2(  1) =    2.62
         Prob > chi2 =    0.1053
. test reg_us=reg_ap
 ( 1)  reg_us - reg_ap = 0
           chi2(  1) =    1.67
         Prob > chi2 =    0.1957
. test reg_us=reg_india
 ( 1)  reg_us - reg_india = 0
          chi2(  1) =    2.56
         Prob > chi2 =    0.1094

. test reg_ap=reg_india
 ( 1)  reg_ap - reg_india = 0
           chi2(  1) =    0.80
         Prob > chi2 =    0.3708
. test reg_ap=reg_eurp
 ( 1)  - reg_eurp + reg_ap = 0
          chi2(  1) =    0.86
 Prob > chi2 =    0.3547
```

Table B.7 : US region individually included in average cost model in Table 5.5.

```
. xtreg ac indep horiz vert_silo multi  diff icsd tal time reg_us  bo exch
csd, re vce(robust)
Random-effects GLS regression                   Number of obs      =       161
Group variable: entno                           Number of groups   =        34
R-sq:                                           Obs per group:
     within  = 0.1741                                         min =          1
     between = 0.5573                                         avg =        4.7
     overall = 0.5418                                         max =          5
                                                Wald chi2(12)      =     54.32
corr(u_i, X)   = 0 (assumed)                    Prob > chi2        =    0.0000
                                 (Std. Err. adjusted for 34 clusters in entno)
------------------------------------------------------------------------------
          ac |     Coef. Robust St.Err.    z     P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       indep |   .4350964   .3300226     1.32   0.187    -.2117359    1.081929
       horiz |  -.4729059   .3907901    -1.21   0.226     -1.23884    .2930286
   vert_silo |   .0852168   .1968537     0.43   0.665    -.3006094    .4710429
       multi |  -.1268684   .1412868    -0.90   0.369    -.4037853    .1500486
        diff |  -.3787279   .3709022    -1.02   0.307    -1.105683     .348227
        icsd |   2.065326   .8542765     2.42   0.016     .3909752    3.739677
         tal |   .0500824   .0256484     1.95   0.051    -.0001875    .1003523
        time |  -.0649161   .0274036    -2.37   0.018    -.1186262    -.011206
      reg_us |  -.6995927   .3033012    -2.31   0.021    -1.294052   -.1051332
          bo |  -.3026953   .2551695    -1.19   0.236    -.8028184    .1974279
        exch |   .1868183   .3957605     0.47   0.637    -.5888581    .9624946
         csd |    .056925   .3308015     0.17   0.863     -.591434    .7052841
       _cons |   .4721187   .5174907     0.91   0.362    -.5421445    1.486382
-------------+----------------------------------------------------------------
     sigma_u |  .68101183
     sigma_e |   .2724702
         rho |  .86201181   (fraction of variance due to u_i)
```

Table B.8 : Test for integration and region coefficients in average cost model in Table 5.6.

```
. test horiz=indep
 ( 1)  - indep + horiz = 0
          chi2(  1) =    2.41
        Prob > chi2 =    0.1206
. test horiz=vert_silo
 ( 1)  horiz - vert_silo = 0
         chi2(  1) =    4.58
        Prob > chi2 =    0.0323
. test horiz=multi
 ( 1)  horiz - multi = 0
         chi2(  1) =    2.54
        Prob > chi2 =    0.1107

. test reg_us=reg_eurp
 ( 1)  reg_us - reg_eurp = 0
          chi2(  1) =    5.45
        Prob > chi2 =    0.0196
. test reg_us=reg_ap
 ( 1)  reg_us - reg_ap = 0
          chi2(  1) =    0.98
        Prob > chi2 =    0.3223
. test reg_us=reg_india
 ( 1)  reg_us - reg_india = 0
         chi2(  1) =    1.61
        Prob > chi2 =    0.2043
. test reg_ap=reg_india
 ( 1)  reg_ap - reg_india = 0
          chi2(  1) =    0.44
        Prob > chi2 =    0.5064
. test reg_ap=reg_eurp
 ( 1)  - reg_eurp + reg_ap = 0
          chi2(  1) =    3.12
        Prob > chi2 =    0.0774
```

Table B.9 : Vertical integration excluded in average cost model in Table 5.6.

```
. xtreg ac indep  diff tal time reg_us reg_eurp reg_ap reg_india bo if
exch==1, re vce(robust)
Random-effects GLS regression                   Number of obs      =       109
Group variable: entno                           Number of groups   =        22
R-sq:                                           Obs per group:
     within  = 0.1798                                          min =         4
     between = 0.5288                                          avg =       5.0
     overall = 0.4921                                          max =         5
                                                Wald chi2(9)       =    222.22
corr(u_i, X)   = 0 (assumed)                    Prob > chi2        =    0.0000
                                 (Std. Err. adjusted for 22 clusters in entno)
------------------------------------------------------------------------------
             |               Robust
          ac |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       indep |  -.3078238   .4996852    -0.62   0.538    -1.287189    .6715412
        diff |  -1.068575   .4934861    -2.17   0.030     -2.03579   -.1013598
         tal |   -.022714   .0264906    -0.86   0.391    -.0746345    .0292066
        time |  -.0512618   .0344531    -1.49   0.137    -.1187887     .016265
      reg_us |  -1.008125   .3789731    -2.66   0.008    -1.750898   -.2653511
    reg_eurp |   .2361368   .4826582     0.49   0.625    -.7098559     1.18213
      reg_ap |  -.3889726   .1833492    -2.12   0.034    -.7483304   -.0296147
   reg_india |  -.3574475   .1298408    -2.75   0.006    -.6119308   -.1029642
          bo |  -.1782291   .1753367    -1.02   0.309    -.5218828    .1654246
       _cons |   1.893049   .5910539     3.20   0.001     .7346045    3.051493
-------------+----------------------------------------------------------------
     sigma_u |  .41520815
     sigma_e |  .26789406
         rho |  .70607083   (fraction of variance due to u_i)
```

Table B.10: US and Europe individually included in average cost model in Table 5.6.

```
. xtreg ac indep horiz vert_silo multi diff tal time reg_us bo if exch==1, re
vce(robust)
Random-effects GLS regression                   Number of obs      =       109
Group variable: entno                           Number of groups   =        22
R-sq:                                           Obs per group:
     within  = 0.2004                                        min =           4
     between = 0.4449                                        avg =         5.0
     overall = 0.4137                                        max =           5
                                               Wald chi2(9)       =     74.98
corr(u_i, X)   = 0 (assumed)                    Prob > chi2        =    0.0000

                                 (Std. Err. adjusted for 22 clusters in entno)
------------------------------------------------------------------------------
          ac |      Coef.  Robust St.Err.   z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       indep |  -.0655417   .4840109    -0.14   0.892    -1.014186    .8831023
       horiz |  -.2602437    .167837    -1.55   0.121    -.5891982    .0687107
   vert_silo |   .2325612   .2317531     1.00   0.316    -.2216666     .686789
       multi |   -.159384   .1010365    -1.58   0.115    -.3574119    .0386438
        diff |  -1.101596   .5739507    -1.92   0.055    -2.226519    .0233267
         tal |   .0173807   .0243363     0.71   0.475    -.0303177     .065079
        time |  -.0574601   .0379084    -1.52   0.130    -.1317592     .016839
      reg_us |   -.950187   .4345541    -2.19   0.029    -1.801897   -.0984766
          bo |  -.4127194   .2953011    -1.40   0.162    -.9914989    .1660601
       _cons |   1.509632   .5349974     2.82   0.005     .4610566    2.558208
-------------+----------------------------------------------------------------
     sigma_u |  .55964978
     sigma_e |  .26928386
         rho |  .81200487   (fraction of variance due to u_i)
------------------------------------------------------------------------------
. xtreg ac indep horiz vert_silo multi  diff  tal time reg_eurp bo if exch==1,
re vce(robust)
Random-effects GLS regression                   Number of obs      =       109
Group variable: entno                           Number of groups   =        22
R-sq:                                           Obs per group:
     within  = 0.1656                                        min =           4
     between = 0.5617                                        avg =         5.0
     overall = 0.5124                                        max =           5
                                                Wald chi2(9)       =     76.06
corr(u_i, X)   = 0 (assumed)                    Prob > chi2        =    0.0000

                                 (Std. Err. adjusted for 22 clusters in entno)
------------------------------------------------------------------------------
          ac |    Coef.  Robust St.Err.   z    P>|z|    [95% Conf. Interval]
-------------+----------------------------------------------------------------
       indep |  -.1276744   .5165851    -0.25   0.805    -1.140162    .8848137
       horiz |   -1.09896   .4674293    -2.35   0.019    -2.015105   -.1828157
   vert_silo |   .2059355   .1936717     1.06   0.288     -.173654     .585525
       multi |  -.3583851   .2202408    -1.63   0.104    -.7900491     .073279
        diff |  -.8273593   .3599072    -2.30   0.022    -1.532764   -.1219542
         tal |  -.0180164   .0282044    -0.64   0.523     -.073296    .0372632
        time |  -.0525158   .0353846    -1.48   0.138    -.1218683    .0168367
    reg_eurp |   1.018917    .521852     1.95   0.051    -.0038937    2.041729
          bo |  -.1291767   .2065622    -0.63   0.532    -.5340311    .2756777
       _cons |   1.286839   .3961427     3.25   0.001     .5104135    2.063265
-------------+----------------------------------------------------------------
     sigma_u |  .42334315
     sigma_e |  .26928386
         rho |  .71194189   (fraction of variance due to u_i)
```

Table B.91: Test for integration and region coefficients in average cost model in Table 5.7.

```
.  test multi=indep
 ( 1)  - indep + multi = 0
           chi2(  1) =    1.35
         Prob > chi2 =    0.2456
. test multi=horiz
 ( 1)  - horiz + multi = 0
           chi2(  1) =    0.34
         Prob > chi2 =    0.5599
. test multi=vert_silo
 ( 1)  - vert_silo + multi = 0
           chi2(  1) =    2.55
         Prob > chi2 =    0.1100
. test reg_us=reg_eurp
 ( 1)  reg_us - reg_eurp = 0
           chi2(  1) =    1.67
         Prob > chi2 =    0.1962
. test reg_us=reg_ap
 ( 1)  reg_us - reg_ap = 0
           chi2(  1) =    0.02
         Prob > chi2 =    0.8795
. test reg_ap=reg_eurp
 ( 1)  - reg_eurp + reg_ap = 0
           chi2(  1) =    1.14
         Prob > chi2 =    0.2851
```

Table B.12: Test for integration and region coefficients in average cost model in Table 5.8.

```
. test horiz=vert_silo
 ( 1)  horiz - vert_silo = 0
           chi2(  1) =    5.84
         Prob > chi2 =    0.0157
. test horiz=multi
 ( 1)  horiz - multi = 0
           chi2(  1) =    1.07
         Prob > chi2 =    0.3009
 test vert_silo=multi
 ( 1)  vert_silo - multi = 0
           chi2(  1) =    2.84
         Prob > chi2 =    0.0922
. test reg_us=reg_eurp
 ( 1)  reg_us - reg_eurp = 0
           chi2(  1) =    4.00
         Prob > chi2 =    0.0456
. test reg_us=reg_ap
 ( 1)  reg_us - reg_ap = 0
           chi2(  1) =    0.51
         Prob > chi2 =    0.4765
. test reg_ap=reg_eurp
 ( 1)  - reg_eurp + reg_ap = 0
           chi2(  1) =    3.32
         Prob > chi2 =    0.0683
```

Table B.13 : Comparison of exchange CCP vertical integration with other integration categories in average cost model in Table 5.8.

```
. xtreg ac  horiz vert_exccp multi diff tal time reg_us reg_eurp reg_ap  if
bo==0 & exch==1, re vce(robust)
Random-effects GLS regression                   Number of obs     =         69
Group variable: entno                           Number of groups  =         14
R-sq:                                           Obs per group:
     within  = 0.1843                                         min =          4
     between = 0.5478                                         avg =        4.9
     overall = 0.5121                                         max =          5
                                                Wald chi2(9)      =      69.16
corr(u_i, X)   = 0 (assumed)                    Prob > chi2       =     0.0000
                                  (Std. Err. adjusted for 14 clusters in entno)
------------------------------------------------------------------------------
          ac |    Coef.   Robust St.Err.   z     P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       horiz |  -.9184484   .4437519    -2.07   0.038    -1.788186   -.0487107
  vert_exccp |  -.2840354   .2228599    -1.27   0.202    -.7208327    .1527619
       multi |  -.5554403   .3102448    -1.79   0.073    -1.163509    .0526283
        diff |  -1.126929    .689331    -1.63   0.102    -2.477992    .2241353
         tal |    .058283   .0643689     0.91   0.365    -.0678777    .1844437
        time |  -.0864619   .0632405    -1.37   0.172    -.2104111    .0374872
      reg_us |  -1.230608   .8073343    -1.52   0.127    -2.812954    .3517384
    reg_eurp |   .2669476   .5554735     0.48   0.631    -.8217605    1.355656
      reg_ap |  -.7076906   .4903074    -1.44   0.149    -1.668675    .2532944
       _cons |   1.716772   .6636249     2.59   0.010     .4160908    3.017453
-------------+----------------------------------------------------------------
     sigma_u |  .77928162
     sigma_e |  .28709599
         rho |   .8804935   (fraction of variance due to u_i)
```

Table B. 14: Comparison regions in average cost model in Table 5.8.

```
. xtreg ac  horiz vert_silo multi diff  tal time reg_eurp  if bo==0 & exch==1,
re vce(robust)
Random-effects GLS regression                   Number of obs     =         69
Group variable: entno                           Number of groups  =         14
R-sq:                                           Obs per group:
     within  = 0.1535                                         min =          4
     between = 0.5476                                         avg =        4.9
     overall = 0.5085                                         max =          5
                                                Wald chi2(7)      =      22.49
corr(u_i, X)   = 0 (assumed)                    Prob > chi2       =     0.0021
                                  (Std. Err. adjusted for 14 clusters in entno)
------------------------------------------------------------------------------
          ac |    Coef.  Robust St.Err    z     P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       horiz | -.9793474   .4306709    -2.27   0.023    -1.823447   -.1352481
   vert_silo |  .3875886   .2824728     1.37   0.170    -.1660478    .9412251
       multi | -.2843397   .1750231    -1.62   0.104    -.6273788    .0586993
        diff | -.6402268   .5015524    -1.28   0.202    -1.623252    .3427979
         tal | -.0008931   .0413819    -0.02   0.983    -.0820002    .0802141
        time | -.0783078   .0571826    -1.37   0.171    -.1903836    .0337681
    reg_eurp |  .9841625   .5548837     1.77   0.076    -.1033895    2.071715
       _cons |   .961291   .4169001     2.31   0.021     .1441819      1.7784
-------------+----------------------------------------------------------------
     sigma_u |  .58971504
     sigma_e |  .28709599
         rho |  .80839977   (fraction of variance due to u_i)
------------------------------------------------------------------------------
. xtreg ac  horiz vert_silo multi diff  tal time reg_us reg_ap  if bo==0 &
exch==1, re vce(robust)
Random-effects GLS regression                   Number of obs     =         69
Group variable: entno                           Number of groups  =         14
R-sq:                                           Obs per group:
     within  = 0.1780                                         min =          4
     between = 0.5895                                         avg =        4.9
     overall = 0.5495                                         max =          5
                                                Wald chi2(8)      =      90.80
corr(u_i, X)   = 0 (assumed)                    Prob > chi2       =     0.0000
                                  (Std. Err. adjusted for 14 clusters in entno)
------------------------------------------------------------------------------
          ac |    Coef.   Robust St.Err.   z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       horiz | -.4637986   .1783592    -2.60   0.009    -.8133763    -.114221
   vert_silo |  .3919325   .2947595     1.33   0.184    -.1857854    .9696504
       multi | -.2344118   .1603927    -1.46   0.144    -.5487757    .0799521
        diff | -1.206506   .6887817    -1.75   0.080    -2.556493    .1434818
         tal |  .0467678   .0568547     0.82   0.411    -.0646654    .1582011
        time | -.0867605    .061556    -1.41   0.159     -.207408     .033887
      reg_us | -1.281982   .6728378    -1.91   0.057     -2.60072    .0367555
      reg_ap |  -.856294   .4653296    -1.84   0.066    -1.768323    .0557353
       _cons |  1.688771   .4778766     3.53   0.000     .7521501    2.625392
-------------+----------------------------------------------------------------
     sigma_u |  .63488502
     sigma_e |  .28709599
         rho |   .8302295   (fraction of variance due to u_i)
```

Table B.15: Comparison regions in average cost model in Table 5.9.

```
. test reg_india=reg_ap
 ( 1)  reg_india - reg_ap = 0
           chi2(  1) =    8.74
         Prob > chi2 =    0.0031
. xtreg ac  tal time reg_india csd if bo==1, re vce(robust)
Random-effects GLS regression                   Number of obs      =        47
Group variable: entno                           Number of groups   =        11
R-sq:                                           Obs per group:
    within  = 0.0419                                        min =         1
    between = 0.5353                                        avg =       4.3
    overall = 0.4597                                        max =         5
                                                Wald chi2(4)       =     34.10
corr(u_i, X)   = 0 (assumed)                    Prob > chi2        =    0.0000
                            (Std. Err. adjusted for 11 clusters in entno)
------------------------------------------------------------------------------
          ac |   Coef.   Robust St. Err.  z    P>|z|      [95% Conf. Interval]
-------------+----------------------------------------------------------------
         tal | -.1070043   .0427156    -2.51   0.012    -.1907253   -.0232833
        time | -.0024209   .0362524    -0.07   0.947    -.0734742    .0686324
   reg_india | -.5082187   .1127067    -4.51   0.000    -.7291198   -.2873175
         csd | -.4302333   .1714458    -2.51   0.012     -.766261   -.0942057
       _cons |   1.34119   .3359894     3.99   0.000     .6826625    1.999717
-------------+----------------------------------------------------------------
     sigma_u |  .10306284
     sigma_e |   .2547811
         rho |   .1406222   (fraction of variance due to u_i)
------------------------------------------------------------------------------
. xtreg ac  tal time reg_ap csd if bo==1, re vce(robust)
Random-effects GLS regression                   Number of obs      =        47
Group variable: entno                           Number of groups   =        11
R-sq:                                           Obs per group:
    within  = 0.0520                                        min =         1
    between = 0.1653                                        avg =       4.3
    overall = 0.1603                                        max =         5
                                                Wald chi2(4)       =      6.88
corr(u_i, X)   = 0 (assumed)                    Prob > chi2        =    0.1422
                            (Std. Err. adjusted for 11 clusters in entno)
------------------------------------------------------------------------------
          ac |    Coef.  Robust St. Err.   z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         tal | -.0534882   .0598024    -0.89   0.371    -.1706988    .0637223
        time | -.0212808   .0319038    -0.67   0.505    -.0838111    .0412494
      reg_ap | -.2036048   .1085256    -1.88   0.061     -.416311    .0091014
         csd | -.4921042   .2903789    -1.69   0.090    -1.061236    .0770281
       _cons |  .8450138   .5151527     1.64   0.101    -.1646668    1.854694
-------------+----------------------------------------------------------------
     sigma_u |  .30770078
     sigma_e |   .2547811
         rho |    .593257   (fraction of variance due to u_i)
```

APPENDIX C

Table C.1 : Test for fixed or random effects for scale regression.

```
Hausman test for fixed or random effects
                 ---- Coefficients ----
             |      (b)          (B)            (b-B)     sqrt(diag(V_b-V_B))
             |     fixed       random       Difference          S.E.
-------------+----------------------------------------------------------------
        diff |    -.127469    -.0250132       -.1024559               .
       indep |   -.7379831     -.623424       -.1145591               .
   vert_silo |    .1169546     .1073754        .0095792               .
       multi |    .0757731     .1091855       -.0334123               .
         tal |    .0195581     .0238949       -.0043368               .
        time |    .0108278     .0095025        .0013253               .
------------------------------------------------------------------------------
            b = consistent under Ho and Ha; obtained from xtreg
            B = inconsistent under Ha, efficient under Ho; obtained from xtreg
    Test:  Ho:  difference in coefficients not systematic
                  chi2(6) = (b-B)'[(V_b-V_B)^(-1)](b-B) = 932.89
                Prob>chi2 =      0.0000     (V_b-V_B is not positive definite)
```

Table C.2 : Test for entity specific random effects for scale regression.

```
Breusch and Pagan Lagrangian multiplier test for random effects
scale[entno,t] = Xb + u[entno] + e[entno,t]
 Estimated results:
                        |       Var     sd = sqrt(Var)
                ---------+-----------------------------
                   scale |    .130703       .3615286
                       e |   .0020827       .0456366
                       u |   .0609464       .2468732
  Test:   Var(u) = 0
  chibar2(01) =   219.39  Prob > chibar2 =   0.0000
```

Table C.3 : Tests for cross sectional dependence.

```
Frees' test of cross sectional independence =     0.306
       Critical values from Frees' Q distribution
                      alpha = 0.10 :   0.5822
                      alpha = 0.05 :   0.8391
                      alpha = 0.01 :   1.4211
Average absolute value of the off-diagonal elements =     0.531

Pesaran's test of cross sectional independence =     1.365, Pr = 0.1723
       Average absolute value of the off-diagonal elements =     0.484

Friedman's test of cross sectional independence =     9.975, Pr = 0.9999
       Average absolute value of the off-diagonal elements =     0.531
```

Table C.4 : Tests for serial correlation for scale and size variables.

```
Wooldridge test for autocorrelation in panel data for scale and Ln TA
H0: no first-order autocorrelation
    F(  1,      31) =    646.976           Prob > F =      0.0000
```

Table C.5 : Unit root test for scale variable.

```
Hadri LM test for scale
Ho: All panels are stationary              Number of panels  =     31
Ha: Some panels contain unit roots         Number of periods =      5

Time trend:         Included               Asymptotics: T, N -> Infinity
Heteroskedasticity: Robust                                  sequentially
LR variance:        (not used)
------------------------------------------------------------------------------
                    Statistic      p-value
z                   -1.0959        0.8634
```

Table C.6 : Replication of Table 5.22 “Summary results for long-run cost savings and utilization of scale economies” using all output coefficients in log total cost function.

Variable	Scale	Scale non-BO	Scale no-BO exchanges	Scale BO	Esec	Esec non-BO	Esec non-BO exchanges	Ed	Ed non-BO	Ed non-BO exchanges
indep	-.61887121***	-.5596684**	-.04269321		-.04858125**			-.37372582***	-.09611311	
horiz	.01845284	.08794623	-.07145913		.02258913	.06367416		.22317482***	.239927**	-.08437532
vert_silo	.11589341***	.11173099***	.12253449***		.06959935***	.07007837***	.07179323***	.04163839**	.02707232***	.0924566***
multi	.1129902***	.10858458***	.10041113***		.05699923***	.04810056***	.06423318***	.02849126	.04250482*	.05706528***
diff	.02131376	-.04461503	.88068297***		.03377582***	.02521681***		.18256126	.07880015	.82425532***
icsd	-.49558185**	-.31912234			-.04644989	.0305449				
tal	.02535624**	.01450519	.01607209	.10034098***	.00541582	.00448145	.00765871*	.02237599*	.01177195	.0055514
time	.0121578**	.01755538***	.01599801***	.01005558	.01707475***	.01958412***	.01617786***	-.00317434	.00272884	.01284193***
reg_us	.38709704	.29816715	.6191011*		.49953129***	.49717235**	.18453494	.69244689***	.51844046**	.16140172
reg_eurp	.34507421	.23850727	.37763976		.08723394	.01174226	-.06233415	.20516149	.18370175	.05782142
reg_ap	.24526451	.10632931	.2410476	.67216762***	.22906977**	.16066835	.07335671	.20778654*	.16433512	.08130357
reg_india	.03771312			.25739586*	.16566817***			.00357337		
bo	.18135983				-.00632103			.05422901		
exch	.26861816*	.36460361**			-.03280742	-.10186749		.33413401***	.30731335***	
csd	.34289548**	.21268636		.13149968	-.05142958	-.17735362				
constant	-.35941421	-.22076144	-.70034921**	-.55102**	.06761346	.18555092	.16117316	-.62108133***	-.39594191	-.64235538***
chi2	1764.7329	723.5779	.	935.39091	37059.691	1609.7549	381.57075	1213.2962	4645.5735	9065.3582
N	161	114	69	47	141	94	54	106	70	64
rank	16	13	9	5	16	13	7	14	11	9

legend: * p<.1; ** p<.05; *** p<.01

Table C.7 : Tests for significant difference for significant categorical variables in scale regressions in tables 5.12, 5.13, 5.14, 5.15.

```
Regression for use of total scale economies (Table5.12)
--------------------------------------------------------------------------------
 . test indep=horiz
  ( 1)  indep - horiz = 0
           chi2(  1) =   17.97
         Prob > chi2 =    0.0000
 . test indep=multi
  ( 1)  indep - multi = 0
           chi2(  1) =   43.86
         Prob > chi2 =    0.0000
 . test indep=vert_silo
  ( 1)  indep - vert_silo = 0
           chi2(  1) =   56.15
         Prob > chi2 =    0.0000
 . test horiz=vert_silo
  ( 1)  horiz - vert_silo = 0
           chi2(  1) =    0.60
         Prob > chi2 =    0.4390
 . test horiz=multi
  ( 1)  horiz - multi = 0
           chi2(  1) =    0.55
         Prob > chi2 =    0.4566
 . test vert_silo=multi
  ( 1)  vert_silo - multi = 0
           chi2(  1) =    0.00
         Prob > chi2 =    0.9697

Regression for use of total scale economies in non-beneficial owner
markets(Table5.13)
--------------------------------------------------------------------------------
 . test indep=horiz
  ( 1)  indep - horiz = 0
           chi2(  1) =    6.00
         Prob > chi2 =    0.0143
 . test indep=vert_silo
  ( 1)  indep - vert_silo = 0
           chi2(  1) =    6.79
         Prob > chi2 =    0.0092
 . test indep=multi
  ( 1)  indep - multi = 0
           chi2(  1) =    6.66
         Prob > chi2 =    0.0099
 . test vert_silo=multi
  ( 1)  vert_silo - multi = 0
           chi2(  1) =    0.00
         Prob > chi2 =    0.9768
 . test vert_silo=horiz
  ( 1)  - horiz + vert_silo = 0
           chi2(  1) =    0.01
         Prob > chi2 =    0.9128
 . test multi=horiz
  ( 1)  - horiz + multi = 0
           chi2(  1) =    0.01
         Prob > chi2 =    0.9201

Regression for use of total scale economies in exchanges in non-beneficial owner
markets (Table5.14)
--------------------------------------------------------------------------------
 . test vert_silo=horiz
  ( 1)  - horiz + vert_silo = 0
           chi2(  1) =    9.76
         Prob > chi2 =    0.0018
 . test multi=horiz
  ( 1)  - horiz + multi = 0
           chi2(  1) =    4.91
         Prob > chi2 =    0.0266
 . test vert_silo=multi
  ( 1)  vert_silo - multi = 0
           chi2(  1) =    0.71
         Prob > chi2 =    0.3981

Regression for use of total scale economies in beneficial owner markets (Table 5.15)
--------------------------------------------------------------------------------
 test reg_ap=reg_india
  ( 1)  - reg_india + reg_ap = 0
           chi2(  1) =    3.33
         Prob > chi2 =    0.0679
```

Table C.8 : Tests for significant difference for significant categorical variables in securities scale elasticity regressions in tables 5.16, 5.17, 5.18.

Regression for securities scale elasticity coefficients (Table 5.16)

```
. test vert_silo= indep
 ( 1)  - indep + vert_silo = 0
          chi2(  1) =   79.14
        Prob > chi2 =    0.0000
. test vert_silo= horiz
 ( 1)  - horiz + vert_silo = 0
          chi2(  1) =    0.15
        Prob > chi2 =    0.7021
. test vert_silo= multi
 ( 1)  vert_silo - multi = 0
          chi2(  1) =    0.19
        Prob > chi2 =    0.6625
. test horiz=indep
 ( 1)  - indep + horiz = 0
          chi2(  1) =    0.80
        Prob > chi2 =    0.3714
. test multi=indep
 ( 1)  - indep + multi = 0
          chi2(  1) =    9.91
        Prob > chi2 =    0.0016
. test multi=horiz
 ( 1)  - horiz + multi = 0
          chi2(  1) =    0.05
        Prob > chi2 =    0.8174
```

```
. test reg_us=reg_ap
 ( 1)  reg_us - reg_ap = 0
          chi2(  1) =    2.40
        Prob > chi2 =    0.1217
. test reg_us=reg_eurp
 ( 1)  reg_us - reg_eurp = 0
          chi2(  1) =    5.12
        Prob > chi2 =    0.0236
. test reg_us=reg_india
 ( 1)  reg_us - reg_india = 0
          chi2(  1) =    0.54
        Prob > chi2 =    0.4634
. test reg_ap=reg_eurp
 ( 1)  - reg_eurp + reg_ap = 0
          chi2(  1) =    3.17
        Prob > chi2 =    0.0750
. test reg_ap=reg_india
 ( 1)  reg_ap - reg_india = 0
          chi2(  1) =    1.06
        Prob > chi2 =    0.3042
. test reg_eurp=reg_india
 ( 1)  reg_eurp - reg_india = 0
          chi2(  1) =    4.10
        Prob > chi2 =    0.0430
```

Regression for securities scale economies coefficients in non-beneficial owner markets(Table 5.17)

```
. test vert_silo= horiz
 ( 1)  - horiz + vert_silo = 0
         chi2(  1) =    0.01
        Prob > chi2 =    0.9272
. test vert_silo= multi
 ( 1)  vert_silo - multi = 0
          chi2(  1) =    2.41
        Prob > chi2 =    0.1204
. test multi=horiz
 ( 1)  - horiz + multi = 0
          chi2(  1) =    0.10
        Prob > chi2 =    0.7577
```

```
. test reg_us=reg_ap
 ( 1)  reg_us - reg_ap = 0
         chi2(  1) =    3.17
        Prob > chi2 =    0.0752
. test reg_us=reg_eurp
 ( 1)  reg_us - reg_eurp = 0
         chi2(  1) =    4.40
        Prob > chi2 =    0.0360
. test reg_ap=reg_eurp
 ( 1)  - reg_eurp + reg_ap = 0
          chi2(  1) =    1.96
        Prob > chi2 =    0.1615
```

Regression for securities scale economies coefficients in non-beneficial owner markets (Table 5.18)

```
. test vert_silo= multi
 ( 1)  vert_silo - multi = 0
          chi2(  1) =    0.71
        Prob > chi2 =    0.3995
```

```
. test reg_us=reg_eurp
 ( 1)  reg_us - reg_eurp = 0
          chi2(  1) =    6.66
        Prob > chi2 =    0.0099 79
.test reg_us=reg_ap
 ( 1)  reg_us - reg_ap = 0
          chi2(  1) =   15.89
        Prob > chi2 =    0.0001
```

Table C.9 : Tests for significant difference for significant categorical variables in securities scale elasticity regressions in tables 5.19, 5.20, 5.21.

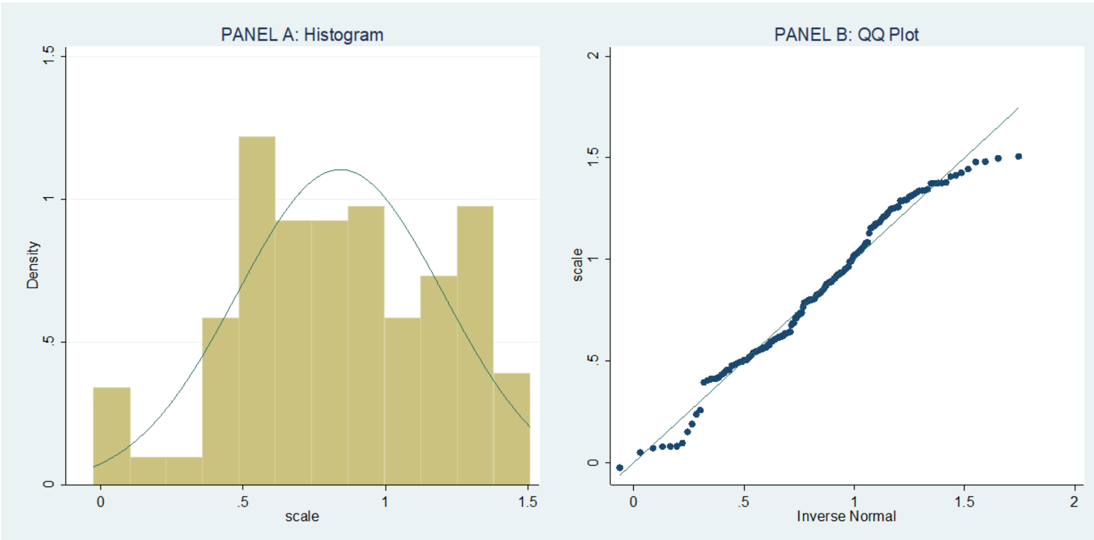
```
Regression for derivatives scale elasticity coefficients (Table 5.19)
-------------------------------------------------------------------------------------
 . test indep=horiz
  ( 1)  indep - horiz = 0
           chi2(  1) =   19.31
          Prob > chi2 =    0.0000
 . test indep=vert_silo
  ( 1)  indep - vert_silo = 0
            chi2(  1) =   13.18
          Prob > chi2 =    0.0003
 . test indep=multi
  ( 1)  indep - multi = 0
            chi2(  1) =   11.40
          Prob > chi2 =    0.0007
 . test horiz=vert_silo
  ( 1)  horiz - vert_silo = 0
            chi2(  1) =   10.75
          Prob > chi2 =    0.0010
 . test horiz=multi
  ( 1)  horiz - multi = 0
            chi2(  1) =    8.21
          Prob > chi2 =    0.0042
 . test reg_us=reg_ap
  ( 1)  reg_us - reg_ap = 0
            chi2(  1) =   10.74
          Prob > chi2 =    0.0010
 . test reg_us=reg_eurp
  ( 1)  reg_us - reg_eurp = 0
            chi2(  1) =    7.53
          Prob > chi2 =    0.0061
 . test reg_us=reg_india
  ( 1)  reg_us - reg_india = 0
            chi2(  1) =    7.19
          Prob > chi2 =    0.0073
 . test reg_ap=reg_eurp
  ( 1)  - reg_eurp + reg_ap = 0
            chi2(  1) =    0.00
          Prob > chi2 =    0.9731
 . test reg_ap=reg_india
  ( 1)  reg_ap - reg_india = 0
            chi2(  1) =    1.27
          Prob > chi2 =    0.2604
```

```
Regression for derivatives scale economies coefficients in non-beneficial owner
markets(Table 5.20)
-------------------------------------------------------------------------------------
 . test indep=horiz
  ( 1)  indep - horiz = 0
            chi2(  1) =   11.82
          Prob > chi2 =    0.0006
 . test indep=vert_silo
  ( 1)  indep - vert_silo = 0
            chi2(  1) =    2.37
          Prob > chi2 =    0.1235
 . test indep=multi
  ( 1)  indep - multi = 0
            chi2(  1) =    2.28
          Prob > chi2 =    0.1313
 . test horiz=vert_silo
  ( 1)  horiz - vert_silo = 0
            chi2(  1) =    5.49
          Prob > chi2 =    0.0192
 . test horiz=multi
  ( 1)  horiz - multi = 0
            chi2(  1) =    4.35
          Prob > chi2 =    0.0370
 . test reg_us=reg_ap
  ( 1)  reg_us - reg_ap = 0
            chi2(  1) =   15.65
          Prob > chi2 =    0.0001
 . test reg_us=reg_eurp
  ( 1)  reg_us - reg_eurp = 0
            chi2(  1) =    7.59
          Prob > chi2 =    0.0059
 . test reg_ap=reg_eurp
  ( 1)  - reg_eurp + reg_ap = 0
            chi2(  1) =    0.05
          Prob > chi2 =    0.8180
```

```
Regression for derivatives scale economies coefficients in non-beneficial owner
markets (Table 5.21)
-------------------------------------------------------------------------------------
 . test vert_silo=horiz
  ( 1)  - horiz + vert_silo = 0
            chi2(  1) =    0.07
          Prob > chi2 =    0.7863
 . test vert_silo=multi
  ( 1)  vert_silo - multi = 0
            chi2(  1) =    0.34
          Prob > chi2 =    0.5614
 . test horiz=multi
  ( 1)  horiz - multi = 0
            chi2(  1) =    0.02
          Prob > chi2 =    0.8840
 . test reg_us=reg_ap
  ( 1)  reg_us - reg_ap = 0
            chi2(  1) =   24.90
          Prob > chi2 =    0.0000
 . test reg_us=reg_eurp
  ( 1)  reg_us - reg_eurp = 0
            chi2(  1) =    2.48
          Prob > chi2 =    0.1150
 . test reg_ap=reg_eurp
  ( 1)  - reg_eurp + reg_ap = 0
            chi2(  1) =    0.79
          Prob > chi2 =    0.374
```

Table C.10: Tests for availability of economies of scale.

```
One-sample t test for scale=1
Variable |      Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
   scale |      161    .8412098    .0284924    .3615286      .78494    .8974796
------------------------------------------------------------------------------
    mean = mean(scale)                                            t =  -5.5731
Ho: mean = 1                                     degrees of freedom =      160
    Ha: mean < 1                 Ha: mean != 1                 Ha: mean > 1
 Pr(T < t) = 0.0000         Pr(|T| > |t|) = 0.0000          Pr(T > t) = 1.0000
------------------------------------------------------------------------------
One-sample Kolmogorov-Smirnov test against theoretical distribution for scale=1
 Smaller group        D       P-value
  scale:               0.0000    1.000
 Cumulative:         -1.0000    0.000
 Combined K-S:        1.0000    0.000
```



Panel A: histogram and normal density plot. Panel B: Quintile plot for scale and normal distribution. Skewness and kurtosis test for normality: number of observations= 161, pr(skewness)= 0.4778, pr(kurtosis)= 0.0234, joint adj chi2(2)= 5.54, joint prob>chi2 = 0.0628.

Figure C.1 : Distribution of scale variable.

APPENDIX D

Table D.1 : Test for fixed or random effects for NPR regression.

```
Hausman test for fixed or random effects
                 ---- Coefficients ----
             |      (b)          (B)            (b-B)     sqrt(diag(V_b-V_B))
             |     fixed        random       Difference          S.E.
-------------+----------------------------------------------------------------
        diff |    .4955547      .375967        .1195877        .1545054
        data |   -.3242179    -.3078407       -.0163772        .0209011
       indep |    .1924546     .1232613        .0691934        .2597249
   vert_silo |    .0399566     .0425532       -.0025966        .1458229
       multi |    .1854118     .0532192        .1321926        .1297211
         tal |    .0331731     .0296391        .0035341        .0219344
        time |    .0001849     .0009429        -.000758        .0032502
------------------------------------------------------------------------------
            b = consistent under Ho and Ha; obtained from xtreg
            B = inconsistent under Ha, efficient under Ho; obtained from xtreg
    Test:  Ho:  difference in coefficients not systematic
                  chi2(7) = (b-B)'[(V_b-V_B)^(-1)](b-B)  =  2.42
                Prob>chi2 =      0.9329   (V_b-V_B is not positive definite)
```

Table D.2 : Test for entity specific random effects for NPR regression.

```
Breusch and Pagan Lagrangian multiplier test for random effects
        npr[entno,t] = Xb + u[entno] + e[entno,t]
        Estimated results:
                         |       Var     sd = sqrt(Var)
                ---------+-----------------------------
                     npr |   .1318155        .363064
                       e |    .030893       .1757642
                       u |    .079923       .2827065
    Test:   Var(u) = 0
    chibar2(01) =    71.08    Prob > chibar2 =   0.0000
```

Table D.3: Tests for cross sectional dependence .

```
Frees' test of cross sectional independence =     1.135
Critical values from Frees' Q distribution
                      alpha = 0.10 :   0.5822
                      alpha = 0.05 :   0.8391
                      alpha = 0.01 :   1.4211
 Average absolute value of the off-diagonal elements =     0.526

Pesaran's test of cross sectional independence =     1.684, Pr = 0.0922
Average absolute value of the off-diagonal elements =     0.514

Friedman's test of cross sectional independence =     0.000, Pr = 1.0000
Average absolute value of the off-diagonal elements =     0.582
```

Table D.4 : Tests for serial correlation for NPR and size variables.

```
Wooldridge test for autocorrelation in panel data (NPR, Ln TA)
H0: no first-order autocorrelation
    F(  1,      31) =     10.101
           Prob > F =      0.0033
```

Table D.5 : Unit root test for NPR variable.

```
Hadri LM test for npr
Ho: All panels are stationary               Number of panels  =     31
Ha: Some panels contain unit roots          Number of periods =      5

Time trend:         Included                Asymptotics: T, N -> Infinity
Heteroskedasticity: Robust                                   sequentially
LR variance:        (not used)
------------------------------------------------------------------------------
                    Statistic      p-value
z                   -0.8450        0.8010
```

Table D.6 : Random effects GLS regressions for Net Profit Ratio (NPR) of exchanges in beneficial owner markets.

NPR	Coef.	Std.Err.	z	P>z	[95% Conf. Int.]	
Ln TA	0.2505	0.0537	4.6700	0.0000	0.1453	0.3557
time	-0.0426	0.0354	-1.2100	0.2280	-0.1120	0.0267
reg_ap	-0.5964	0.0959	-6.2200	0.0000	-0.7844	-0.4084
reg_india	0.3159	0.0476	6.6400	0.0000	0.2227	0.4092
_cons	-1.2171	0.4066	-2.9900	0.0030	-2.0141	-0.4201
sigma_u	0.0575					
sigma_e	0.2420					
rho	0.0534					

Random Effects GLS Regression. Group variable: entity, number of obs = 40, number of groups = 8, within R-sq = 0.1078, between R-sq= 0.9341, overall R-sq = 0.6776, Wald chi2(4) = 1180.72, corr(u_i, X) = 0 (assumed), prob > chi2= 0.0000, standard errors adjusted for 8 clusters in entities. NPR: net profit ratio, Ln TA: log total assets, time: linear time trend, reg_ap: Asia Pacific, reg_india: India. sigma_u: standard deviation of panel entity-specific time-invariant error term, sigma_e: standard deviation of the idiosyncratic error component, rho: fraction of variance due to u_i.

Table D.7 : Tests for significant difference for significant categorical variables in NPR regressions in tables 5.23, 5.24, 5.25, 5.26, 5.27.

Regression for NPR (Table5.23)

```
. test indep=horiz
 ( 1)  indep - horiz = 0
           chi2(  1) =    2.54
         Prob > chi2 =    0.1111
. test vert_silo=horiz
 ( 1)  - horiz + vert_silo = 0
           chi2(  1) =    3.36
         Prob > chi2 =    0.0670
. test multi=horiz
 ( 1)  - horiz + multi = 0
           chi2(  1) =    3.12
         Prob > chi2 =    0.0772
. test indep=vert_silo
 ( 1)  indep - vert_silo = 0
           chi2(  1) =    0.54
         Prob > chi2 =    0.4625
. test indep=multi
 ( 1)  indep - multi = 0
           chi2(  1) =    0.15
         Prob > chi2 =    0.7018
. test multi=vert_silo
 ( 1)  - vert_silo + multi = 0
           chi2(  1) =    0.00
         Prob > chi2 =    0.9481
. test reg_us=reg_eurp
```

Regression for NPR in exchanges (Table 5.24)

```
. test indep=horiz
 ( 1)  indep - horiz = 0
           chi2(  1) =    0.47
         Prob > chi2 =    0.4920
. test horiz=vert_silo
 ( 1)  horiz - vert_silo = 0
          chi2(  1) =    0.03
         Prob > chi2 =    0.8535
. test vert_silo=multi
 ( 1)  vert_silo - multi = 0
           chi2(  1) =    0.42
         Prob > chi2 =    0.5154
```

Regression for NPR in non-beneficial owner markets (Table5.25)

```
. test horiz=indep
 ( 1)  - indep + horiz = 0
           chi2(  1) =    1.34
         Prob > chi2 =    0.2474
. test horiz=vert_silo
 ( 1)  horiz - vert_silo = 0
          chi2(  1) =    1.84
         Prob > chi2 =    0.1748
. test horiz=multi
 ( 1)  horiz - multi = 0
           chi2(  1) =    0.43
         Prob > chi2 =    0.5103
. test multi=vert_silo
 ( 1)  - vert_silo + multi = 0
           chi2(  1) =    0.77
         Prob > chi2 =    0.3808
. test multi=indep
( 1)  - indep + multi = 0
           chi2(  1) =    0.72
         Prob > chi2 =    0.3949
. test reg_ap=reg_us
 ( 1)  - reg_us + reg_ap = 0
           chi2(  1) =    0.11
         Prob > chi2 =    0.7432
. test reg_ap=reg_eurp
 ( 1)  - reg_eurp + reg_ap = 0
           chi2(  1) =    1.21
         Prob > chi2 =    0.2715
```

Regression for use of total scale economies in exchanges in non-beneficial owner markets (Table5.26)

```
. test multi=horiz
 ( 1)  - horiz + multi = 0
           chi2(  1) =    1.85
         Prob > chi2 =    0.1743
. test multi=vert_silo
 ( 1)  - vert_silo + multi = 0
           chi2(  1) =    0.70
         Prob > chi2 =    0.4027
. test reg_us=reg_ap
 ( 1)  - reg_us + reg_ap = 0
           chi2(  1) =    0.05
         Prob > chi2 =    0.8294
. test reg_ap=reg_eurp
 ( 1)  - reg_eurp + reg_ap = 0
           chi2(  1) =    0.26
         Prob > chi2 =    0.6119
```

Regression for NPR in beneficial owner markets (Table 5.27)

```
test reg_ap=reg_india
 ( 1)  - reg_india + reg_ap = 0
           chi2(  1) =    3.33
         Prob > chi2 =    0.0679
```

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PUBLICATIONS, PRESENTATIONS AND PATENTS ON THE THESIS:

- **Ipek, S.,** and Ekinci, C. (2017). Sermaye Piyasalari Altyapı Kurumlarının Endüstriyel Yapılanması/Industrial Organization of Capital market infrastructure Institutions. *Finans Politik & Ekonomik Yorumlar*, 54(623), 77.
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