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Economies of scale and technological development in securities depository and settlement systems

Suomen Pankin keskustelualoitteita
Finlands Banks diskussionsunderlag

Suomen Pankki
Bank of Finland
P.O.Box 160
FIN-00101 HELSINKI
Finland
☎ + 358 9 1831

http://www.bof.fi

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* Corresponding author: HWWA-Hamburg Institute of International Economics and Research Department Bank of Finland, e-mail: schmiedel@hwwa.de.

** Evli Bank Plc., e-mail: markku.malkamaki@evli.fi.

*** Research Department, Bank of Finland, email: juha.tarkka@bof.fi.

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Economies of scale and technological development in securities depository and settlement systems

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Abstract

The paper investigates the existence and extent of economies of scale in depository and settlement systems. Evidence from 16 settlement institutions across different regions for the years 1993–2000 indicates the existence of significant economies of scale. The degree of such economies, however, differs by size of settlement institution and region. While smaller settlement service providers reveal high potential of economies of scale, larger institutions show an increasing trend of cost effectiveness. Clearing and settlement systems in countries in Europe and Asia report substantially larger economies of scale than those of the US system. European cross-border settlement seems to be more cost intensive than that on a domestic level, reflecting chiefly complexities of EU international securities settlement and differences in the scope of international settlement services providers. The evidence also reveals that investments in implementing new systems and upgrades of settlement technology continuously improved cost effectiveness over the sample period.

Key words: securities settlement, economies of scale, technological progress

JEL classification numbers: D4, G20, F36, L22, O33

Skaalaedut ja tekninen kehitys arvopaperikaupan rekisteri- ja selvitysjärjestelmissä

Suomen Pankin keskustelualoitteita 26/2002

Heiko Schmiedel – Markku Malkamäki – Juha Tarkka
Tutkimusosasto

Tiivistelmä

Tässä tutkimuksessa tarkastellaan skaalaetujen olemassaoloa ja suuruutta arvopaperikaupan rekisteri- ja selvitysjärjestelmissä. Tutkimuksessa oli mukana 16 selvityskeskusta eri puolilta maailmaa vuosina 1993–2000, ja sen tulokset osoittavat, että toiminnan skaalaedut alalla ovat merkittävät. Skaalaetujen suuruus vaihtelee kuitenkin sen mukaan, mikä on selvityskeskuksen koko ja sijainti. Hyödyntämättömät skaalaedut ovat suurimmat pienissä selvityskeskuksissa, ja suurimmat selvityskeskukset ovat parantaneet kustannustehokkuuttaan eniten. Eurooppalaisissa ja aasialaisissa selvitys- ja toimitusjärjestelmissä on enemmän hyödyntämättömiä skaalaetuja kuin Yhdysvaltain järjestelmässä. Eurooppalaiset kansainväliset selvityskeskukset näyttävät olevan kustannuksiltaan kalliimpia kuin kotimaiset selvitysjärjestelmät, mikä kuvastaa kansainvälisen selvitystoiminnan monimutkaisuutta jopa EU:n sisällä sekä tuotevalikoimien eroja eri selvityskeskusten välillä. Tulokset paljastavat myös, että investoinnit, joilla on otettu käyttöön uusia järjestelmiä ja parannettu toiminnan teknistä tasoa, ovat lisänneet tehokkuutta tarkastellun ajanjakson kuluessa.

Asiasanat: arvopaperien selvitys, skaalatuotot, tekninen kehitys

JEL-luokittelu: D4, G20, F36, L22, O33

Contents

1 Introduction

1.1 Observations and motivation

The most notable features of major trends in global capital markets are that they witness pressures of globalisation and consolidation. Technological innovations and a changing regulatory environment were fundamental catalysts behind these structural changes in modern financial markets. Technological advances have been causing less dependency on physical market locations thus exposing market participants to an increasingly competitive new environment in domestic markets as well as in the global arena. Equally important, is the growing interest among institutional and individual investors to maximize the positive effects from international portfolio diversification resulting in a rapid expansion in trading internationally (Gehrig (1998a, 1998b), Hasan, Malkamäki, and Schmiedel (2002), Malkamäki and Topi (2002), Smith (1991), and Stulz (1999)).

All these developments are acutely relevant for the securities market infrastructure, ie for the securities settlement services for equities, interest-bearing instruments and derivatives. The importance derives from the fact that clearance and settlement costs can be viewed as a subset of the transaction costs facing an investor in effecting a trade (Giddy, Saunders, and Walter (1996)). At present, in particular in the European context where institutional arrangements for clearing and settling securities remain fragmented along national lines, making cross-border trading costly, such costs deserve particular attention. This paper addresses the costs associated with depository and settlement businesses and it anticipates potential cost savings from consolidation and concentration of the industry.

The present paper deals with a number of research issues that have emerged in the forefront of clearing and settlement debate: the first is to analyse whether the securities settlement is a business where essentially scale matters and whether there exist significant economies of scale in the function of settlement services. If this is the case, what is the extent of such scale economies? Do potential cost savings differ across types, size, and regions? In particular, how cost-efficient are the European systems compared to other international experiences? What are the implications for the structure of the settlement industry? Would it result in the dominance of a new large or few super regional settlement service providers making the existence of relatively smaller institutions obsolete?

1.2 Clearing and settlement

Clearance and settlement services are essential requisites of a well functioning securities market. Clearing involves the process of establishing the respective obligations of the buyer and the seller in a security trade, while settlement comprises the actual transfer of securities from the seller to the buyer. Three types of clearance-settlement organisations provide these services: domestic central securities depositories (CSDs), international central securities (ICSDs) and custodians.

The settlement infrastructure has traditionally been most integrated in US securities markets. The latest step in the consolidation process in the US has been the integration of the operations of the Depository Trust Company (DTC) and the National Securities Clearing Cooporation (NSCC) under a common holding company, the Depository Trust & Clearing Corporation (DTCC). Together, the companies and their affiliates clear and settle virtually all securities transactions in the US market, while the DTC remains the world's largest securities depository.

In contrast to the United States, the securities settlement and depository infrastructure in the European Union is still quite fragmented, although some efforts towards a more integrated infrastructure are well paving its way. At the national level, the integration of CSDs and settlement houses is already relatively far advanced, so that the emphasis is now on the need for reforms in the cross-border settlement of securities.

The fragmentation of the EU clearing and settlement infrastructure also differs across the main securities markets. For example, in debt markets, two international central securities depositories (ICSDs), Euroclear Bank and Clearstream International, already play a dominant role. The ICSDs were originally established to carry out settlement services for the Eurobond market. Nowadays they provide settlement processing for most types of fixed-income trades and to a lesser extent equity transactions. However, in equity markets settlement is processed in a plethora of national systems involving varying technical requirements, market practices, fiscal procedures and legal environments. Consequently, cross-border clearing and settlement of equities is more problematic than in bond markets.

However, some attempts point towards cross-border consolidation in the European clearing and settlement industry as evidenced by the recent merger of Deutsche Börse Clearing and Cedelbank Luxembourg under the name Clearstream International. Here, the purpose is to actively achieve economies of scale by vertically integrating trading, clearing, and settlement services in a single institution. Other initiatives involve ongoing attempts to integrate each Euronext members' settlement system under Euroclear Group, while the announced merger plans between Euroclear and CrestCo UK exemplify horizontal consolidation between domestic trading/clearing/settling systems for different securities, ie fixed income and equities, or cross-border between two or more national systems for the same kind of instruments.[1]

1.3 Literature review

We are not aware of any empirical study particularly dealing with economies of scale in the depository and settlement industry. Several authors analysed and discussed alternative models for clearance and settlement within a single European capital market. Giddy, Saunders, and Walter (1996) examine barriers to European financial market integration associated with imperfections and frictions imbedded in the clearance and settlement of cross-border trade. Comparing cross-country descriptive statistics of the securities industry in the EU, Lannoo and Levin (2001) observe that operating costs of securities settlement systems in the EU are higher than in the US, although the difference is not as high as often proclaimed. A comprehensive assessment of current arrangements for cross-border clearing and settlement is presented in Giovannini Group (2002).

1.4 Analysis and organization

This paper attempts to void the gap in the literature with a comprehensive panel based analysis on economies of scale across all major global depository and settlement institutions over the 1993–2000 period. This is one of the very first comprehensive attempts in providing separate perspectives on scale effects across different types, sub-groups, and geographical location of settlement service providers. In related studies, a few researchers examine economies of scale, relative efficiency, and technological development in the stock exchange industry from a European and global perspective (Hasan, Malkamäki, and Schmiedel (2002) and Schmiedel (2001 and 2002). Following the stock exchange literature (Arnold et al (1999), Domowitz and Steil (1999), and Pirrong (1999)), depository and settlement services providers are herein considered as operative firms. This approach is of great importance for the evolution of the market structure and contestability of the markets because also settlement institutions make choices concerning, for example, their trading technologies, ie supply side of their settlement services. Domowitz and Steil (1999) argue further that industrial structure of market places cannot be explained by focusing on the demand side

[1] See also Giddy, Saunders, and Walter (1996) and Malkamäki and Topi (2002) for a discussion on settlement structures in Europe.

alone, as it is the case in financial market microstructure studies. It is equally important to know more about the supply side, ie the provision of settlement services.

The overall results of this study reveal the existence of substantial economies of scale among depository and settlement institutions. On average, the centralised US system is found to be the most cost effective settlement system and may act as the cost saving benchmark. However, settlement institutions from Europe and Asia-Pacific regions show highest potential in unit cost savings. Similar results were found for relatively smaller service providers where a doubling of settlement and depository activities would increase cost by 2/3. The findings also suggest that operating costs for carrying out cross-border settlement appear to be much higher than operating a domestic CSD reflecting the current complexities of EU international securities settlement and differences in the underlying scope of ICSD services. Moreover, the evidence indicates that operating cost decreased continuously over time, possibly due to investments in implementing new systems or upgrading settlement technology. Consistent with the Giovannini Group (2002), this paper stresses on the importance that the removal of cost inefficiencies in clearing and settlement is a necessary condition for the development of a large and efficient financial infrastructure in particular in Europe.

The paper is organized as follows. Section 2 develops the model of estimating settlement system's economies of scale. It follows a description and statistics of the data. Section 4 addresses empirical results, while section 5 concludes.

2 The model

2.1 Measurement issues

Following the literature on stock exchanges (Arnold et al (1999), Domowitz and Steil (1999), and Pirrong (1999)), each settlement institution is assumed to be a multiproduct firm that incurs operating costs while producing different outputs and using inputs. In general, it is controversial what constitutes inputs or outputs for any financial institution. It is even more difficult to do so for the settlement institutions and it is even not obvious what constitutes the relevant market of the settlement industry. In general, securities settlement systems mainly provide settlement and depository services. Settlement refers to the actual transfer of a security while depository is the safekeeping of assets and the administration of securities on behalf of intermediaries and investors. A close look at the operations and annual reports of settlement institutions would confirm such notions of two functions producing two outputs.

In order to assess cost/income structures and to calculate economies of scale in the settlement industry, it is important to define relevant proxies of the costs, outputs, and inputs for a settlement system. We are aware of methodological particularities of making direct comparisons of the fees charged to market participants, since each settlement institution elaborated its own complex fee structure and pricing scheme depending on the type of transaction, its volume, and the size and nature of the client (see also Lannoo and Levin (2001)). Following this justification, the total cost variable in this study represents the reported operating expenses of a settlement system including depreciation. Similarly, the operating income of a settlement system serves as a proxy of settlement income. Both variables are based on publicly available information, which can be found in each institution's financial statements of annual reports.

Concerning the output relating to the settlement procedure and depository activities, we consider two direct measures. One possible proxy for the settlement service might be the number of securities settled in the system (NSETT), while the output for the depository business might be proxied by the value of securities deposited in the system (VDEP). There are no direct measures available for inputs of settlement institutions. The statements in the annual reports reveal that the two most important input prices for the operations of settlement institutions are the settlement system comprising technology and office expenses and the personnel costs.

Disaggregated system cost and labour data is unavailable for many of the annual reports. In order to include at least one relevant input price variable, the GDP (Gross Domestic Product) per capita is used to act as a proxy for differences in labour costs across countries. Interestingly, in similar studies on the stock exchange industry (Hasan and Malkamäki (2001), Hasan, Malkamäki, and Schmiedel (2002)), the estimations using per capita GDP as labour input proxy do not yield significantly different results compared to estimations that actually use the direct measure of labour price as an input.

Most of the sample institutions in this paper are domestic CSD's reflecting the fact that the securities settlement has traditionally been carried out by domestic CSD on a national level in the European area. Differing historical, institutional, technical, and legal environments led to a fragmented settlement industry, which was unable to address adequately the growing needs of market participants to operate cross-border. However, two international central securities depositories (ICSD's), Euroclear and Clearstream, have been established in order to capture the settlement market of internationally traded securities. These institutions also differ in many aspects concerning the scope of instruments, environments, and services from their domestic counterparts. The ICSD's primarily focus on the settlement of fixed income instruments, but nevertheless for equity transactions as well. ICSD's are also engaged in different markets dealing with multiple currencies and different regulatory environment and requiring more complex services and advanced system technologies. Moreover, ICSD's provide a number of services that a CSD does not, ie corporate action services.[2] In order to incorporate such differences in reported cost data, we introduce a binary variable in all regression estimations highlighting the two ICSD's whose business activities and cost data might differ from the services and nature of domestic CSD's.

The following are the models we have attempted to estimate with the intention of investigating our research questions with the possibility of including highest numbers of sample institutions in the data set. The starting point of our analysis is a series of rather straightforward loglinear models (Ia–d) regressing total operating cost on the output proxies. In the next step, we estimate translog cost functions of the sample settlement institutions. Models IIa–c depict the single product case including one output (number of settlement instructions processed) and one input (GDP per capita). Models IIIa–c deal with multioutput technologies by incorporating two outputs (number of settlement instructions processed and value of deposited settlement instructions in the system) and keeping the same input as in models II. In each model, we control whether an institution is engaged to settle securities on a cross-border basis. Additionally, models II and III control for technological change by adding either a linear time trend variable and alternatively by including binary variables for each year. The sample period considered in all estimations is 1993–2000. Total operating cost including depreciation represent the dependent variable in all of these models.

2.2 Empirical methodology

A commonly used translog cost function (Berndt 1991) is employed in order to evaluate economies of scale in the settlement industry. The most notable feature of this translog function is that it allows scale economies to vary with the level of output. The general functional form of the multiproduct translog cost function can be written as

$$\begin{aligned}\ln TC(P,Q,D,T,YR) = {} & \alpha_0 + \alpha_1 \ln Q_1 + \alpha_2 \ln Q_2 + \beta_{11}(\ln Q_1)^2 + \beta_{22}(\ln Q_2)^2 + \\ & + \sum_i \gamma_i \ln P_i + \sum_i \sum_j \gamma_{ij} \ln P_i \ln P_j + \beta_{12} \ln Q_1 \ln Q_2 + \\ & + \sum_i \sum_k \delta_{ik} \ln P_i \ln Q_k + \lambda_1 D_1 + \tau_1 T + \sum_l \delta_l YR_l \end{aligned} \tag{3.1}$$

[2] See Table 11 in Lannoo and Levin (2001) for an overview of different services provided by ICSD's and CSD.

The total costs, TC, depend on the vector of output, Q, the vector of factor prices, P, for each institution and over time. The variable (D) equals unity for ICSD and zero otherwise. Scale elasticity coefficients with respect to the two outputs are calculated as follows

$$\varepsilon_1^c = \frac{\partial \ln TC}{\partial \ln Q_1} = \alpha_1 + 2\beta_{11} \ln Q_1 + \beta_{12} \ln Q_2 + \sum_i \delta_{1i} \ln P_i \tag{3.2}$$

$$\varepsilon_2^c = \frac{\partial \ln TC}{\partial \ln Q_2} = \alpha_2 + 2\beta_{22} \ln Q_2 + \beta_{21} \ln Q_1 + \sum_i \delta_{2i} \ln P_i \tag{3.3}$$

Generally, the concept of potential economies of scale maintains that average or unit cost decreases as all outputs are expanded by the same proportion per time period; that is, scale economies are available if the sum of the cost output elasticity is smaller than one, whereas scores above unity implies diseconomies. When a multiproduct cost function $(Q = (Q_1, \ldots, Q_n))$ is assumed, the conventional measure of scale economies is defined as the inverse of the elasticity of Ray average cost. In the case of two outputs it yields

$$\frac{1}{S} = \sum_i \frac{\partial \ln TC}{\partial \ln Q_i} = \varepsilon_1^c(Q_1, Q_2) + \varepsilon_2^c(Q_1, Q_2) \tag{3.4}$$

It is often useful to consider the scale economies along a particular expansion path, eg defined by $Q_1 = f(Q_2)$ (Baumol et al (1988)). In this respect a loglinear expansion path is incorporated in the estimations.

The partial derivative of equation (3.1) with respect to time (T) or to each year (YR) will then measure the technical characteristics of the underlying technology. This provides an indication of the rate of movement in the cost function over time. For technical advancement to occur, the sign of these coefficients should be negative, indicating the cost function is shifting down over time.

If it turns out that the second order terms in the translog model are not any different from zero, the translog function reduces to the special linear case, ie the linear logarithmic Cobb-Douglas cost function. The linear logarithmic model to be estimated is in that case

$$\begin{aligned} \ln TC(P, Q, D, T, YR) = \alpha_0 + (\alpha_1 / r) \ln Q_1 + (\alpha_2 / r) \ln Q_2 + \\ + \sum_i (\gamma_i / r) \ln P_i + \lambda_1 D_1 + \tau_1 T + \sum_l \delta_l YR_l \end{aligned} \tag{3.5}$$

with $\alpha_1 + \alpha_2 = 1$ and $S = r$. As r is a constant, returns to scale cannot vary with the level of output in this model.

3 Data and descriptive statistics

The data used in this study comes from a variety of sources, including annual reports of settlement institutions, various issues of the European Central Bank Blue Book on Payment and Securities Settlement Systems in the European Union, Bank for International Settlement Statistics on Payment and Settlement Systems, IMF International Financial Statistics (IFS), and information from the settlement institutions Internet sites. Most of the data were collected from annual balance sheets, income statement reports, and Internet pages of all major operating settlement institutions covering an eight-year time period (Annual Reports 1993–2000). In some cases, additional information was obtained from the settlement institutions by correspondence. Also Thomas Murray CSD Guide served as an important source to obtain information on settlement institution-specific characteristics. Although reporting schemes and information content of the financial accounts vary across time and settlement institution, a consistent data set has been compiled including all necessary information on 16 individual settlement agencies key balance sheet and income statement items over the period from 1993–2000, which entered the estimations. Table 1 provides an overview of all sample settlement institutions. The sample of settlement institutions has a special focus on the European area and comprises national as well as international EU systems. Additionally, settlement systems from the North American and Asia-Pacific regions are considered in the sample. The US system enters the panel as an example for a monopolistic and centralised system. Table 2 summarizes the variable structure and data sources. All national currencies are converted into US $ and are inflation adjusted using data from IFS. All variables other than the qualitative proxies are expressed in natural logarithms in the regression models.

Table 1. **Summary of sample settlement institutions, 1993–2000**

Region/Code	Settlement institution	Country	CSD/ICSD	Years
Europe				
CED	Clearstream Luxembourg	Luxembourg	ICSD	1999
ECB	Euroclear Bank	United Kingdom	ICSD	1999–2000
Europe (excl. ICDS)				
APK	APK	Finland	CSD	1997–2000
CRE	CrestCo	United Kingdom	CSD	1997–2000
DBC	Clearstream Frankfurt	Germany	CSD	1994–2000
MON	Monte Titoli	Italy	CSD	1996–2000
NEC	Necigef	Netherlands	CSD	1993–1999
SEG	SegaIntersettle	Switzerland	CSD/ICSD	1995–1997; 2000
SIC	Euroclear France (formerly Sicovam)	France	CSD	1999–2000
VP	Danish Securities Centre	Denmark	CSD	1993–2000
VPC	VPC	Sweden	CSD	1995–1998
VPS	Verdipapirsentralen	Norway	CSD	1994–1998
North America				
CDS	Canadian Depository for Securities	Canada	CSD	1993–2000
DTC	Depository Trust & Clearing Company	United States	CSD	1993;1995–2000
Asia Pacific				
HSC	Hong Kong Securities Clearing Company	Hong Kong /China	CSD	1993–1998
JAS	Japan Securities Depository Center	Japan	CSD	1996–1998

Table 2. **Data structure and sources**

Variables	Coefficients	Definition and measurement units	Sources
Cost			
OPCOST	TC	Total operating cost in thousands of US $	Annual reports 1993–2000
Inputs			
GDPC	P_1	Gross domestic product per capita in thousands of US $	IFS Yearbooks
Outputs			
NSETT	Q_1	Number of settlement instructions processed in the system in thousands	Annual reports 1993–2000; ECB (various issues) Blue Book; BIS (various issues) Payment statistics
VDEP	Q_2	Value of settlement instructions processed in the system in millions of US $	Annual reports 1993–2000; ECB (various issues) Blue Book; BIS (various issues) Payment statistics
Others			
TIME	T	Linear time trend variable	
YEAR	YR94-00	Dummy variables for the years 1994–2000	
ICSD	D_1	Binary variable for ICSD = 1, otherwise 0	Annual reports 1993–2000

Table 3 provides an overview of key performance ratios of the sample settlement institutions over the years 1993–2000. It includes settlement institutions from the European area, North America, and Asia-Pacific regions. Moreover, the table reports separate perspectives for the European ICSDs and CSDs and provides aggregated information on the cost and revenue structure for European subsamples. Overall the data varies considerably across different systems, illustrating the diversity of economic conditions and operating systems, the range of services provided by each institution, and to some extent differing financial reporting schemes.

The most readily comparable key measure for cost efficiency is the cost per trade. It gives information on the average "unit cost" for settling a securities market trade in the system. A relative cost comparison shows that the average cost per settled transaction is $3.86 for all European institutions and $2.90 in the US In other words, securities settlement in Europe is 1.33 times more costly than on DTC. The average costs for carrying out cross-border settlement appear to be much higher than operating a domestic CSD, ie $40.54 relative to $3.11 for EU CSDs or to $2.90 for US system. Consistent with Lannoo and Levin (2001), this gab reflects the current complexities of EU international securities settlement and differences in the underlying scope of their services. Considering only CSDs the cost differential vis-à-vis the US the data becomes less dramatic (only EU CSD $3.11 compared to $2.90). However, the lower cost ratio for European CSDs seems to be driven by the cost effective settlement system in the UK ($1.58). All other European domestic systems report scores above average. This is in particular the case for the Finish system with highest average cost per settled instruction of $12.81. Securities trading, clearing, and settlement services are vertically integrated and carried out in various subsidiaries of the HEX Group. Generally, vertical integration may offer a number of positive effects such as increased speed, safety, and risk management. However, the cost data does not support the view of relative cost optimal structures in the Finnish silo model.

A more favourable picture emerges for the cross-border settlement concerning the cost per value of deposited instructions in the system. The ICSDs show almost the same cost effectiveness as their US counterpart ($0.013 versus $0.007), while national CSDs report lower cost efficiency of $0.060. The Asia-Pacific system score lowest in terms of cost per value of deposited securities. The findings of lower cost performance in respect to the number of settled transactions and the higher cost effectiveness for the value of deposited securities reveal that ICSDs are likely to benefit from settling securities instructions from large, international firms which trade low in volume and high in value across borders. This view is also supported by the turnover velocity ratios in the last column in table 7 where EU ICSDs and the US system perform much better compared to national CSDs from other regions.

On the income side, the figures indicate that the EU (EU excl. ICSD) average operating income per settled securities instructions is almost 75% (30%) higher than in the US ($5.10 ($3.82) as compared to $2.92). In other words, the operating revenues cover on average the operating expenditure of European ICSDs and CSD's at a considerable level of 18.29% and 18.52%, respectively. The Asia-Pacific institutions show average operating margins within the range of those from Europe. Both North American systems operate with significantly smaller margins compared to those from other regions. In particular, the operating margin of the centralised system in the US is lower than unity ($0.80) indicating that generated revenues just cover costs.

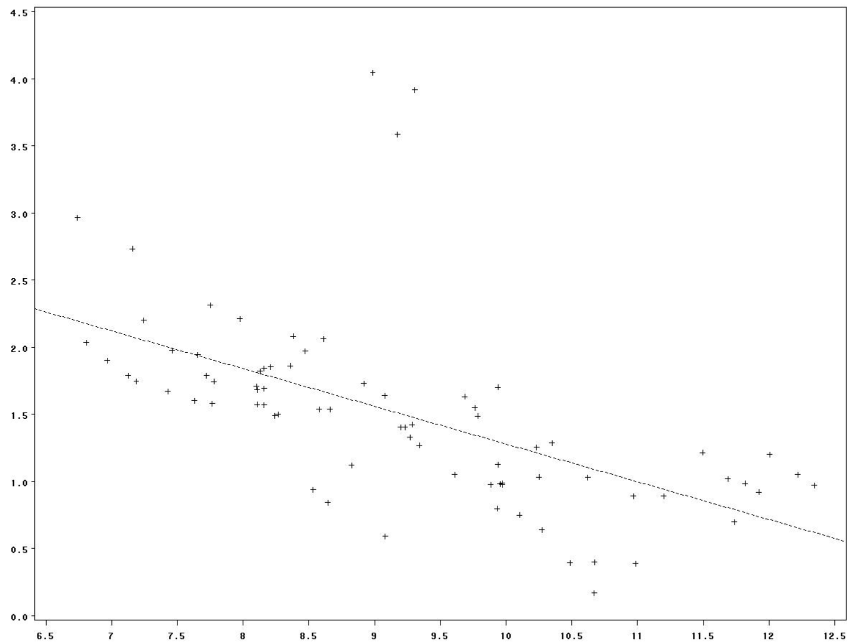
The cost data illustrate that there exist potential economies of scale in the settlement industry. These effects are fairly pronounced for both the number of settlement instructions and for depository activities. These relationships are graphically presented in Figures 1 and 2 below.

Table 3. **Average key performance ratios for selected settlement institutions, 1993–2000**

Years / Region / Code	**OPCOST/NSETT**	**OPINC /NSETT**	**OPMARGIN (%)**	**OPCOST/VDEP**	**OPINC/VDEP**	**NSETT/VDEP**
1993–1996	3.43	3.74	8.18	0.035	0.037	0.0099
1997–2000	3.22	3.77	14.56	0.009	0.011	0.0028
1993–2000	3.33	3.75	11.39	0.022	0.024	0.0063
Europe (ICSD)						
Clearstream Luxembourg	29.02	35.57	18.41	0.015	0.015	0.0008
Euroclear Bank	53.64	65.79	18.46	0.010	0.012	0.0002
Europe (excl. ICSDs)						
APK	12.81	21.60	40.69	0.077	0.091	0.0044
CRE	1.58	2.31	31.37	0.031	0.045	0.0166
DBC	3.72	4.39	15.29	0.033	0.041	0.0125
MON	3.93	6.71	41.46	0.060	0.091	0.0097
NEC	5.88	5.97	1.54	0.035	0.036	0.0072
SEG	6.73	7.80	13.68	0.042	0.050	0.0066
SIC	3.15	4.31	26.83	0.029	0.040	0.0099
VP	5.03	6.13	17.97	0.071	0.088	0.0148
VPC	5.17	6.47	20.00	0.054	0.067	0.0198
VPS	6.43	6.94	7.48	0.141	0.152	0.0196
Europe						
All	3.86	5.10	24.27	0.042	0.060	0.0115
excluding ICSDs	3.11	3.82	18.52	0.060	0.072	0.0204
ICSDs	40.54	49.61	18.29	0.013	0.017	0.0004
North America						
CDS	2.93	3.12	6.37	0.063	0.067	0.0236
DTC	2.90	2.92	0.80	0.007	0.007	0.0026
Asia, Pacific						
HSC	4.42	7.79	43.26	0.100	0.176	0.0212
JAS	2.64	3.22	18.09	0.141	0.150	0.0166

Note: All currency and price-related figures are inflation adjusted and expressed in US \$. OPCOST is operating cost in thousands US \$; OPINC is operating income in thousands US \$; NSETT is the number of settlement instructions processed in thousands; VDEP is the value of securities deposited in the system in millions of US \$.

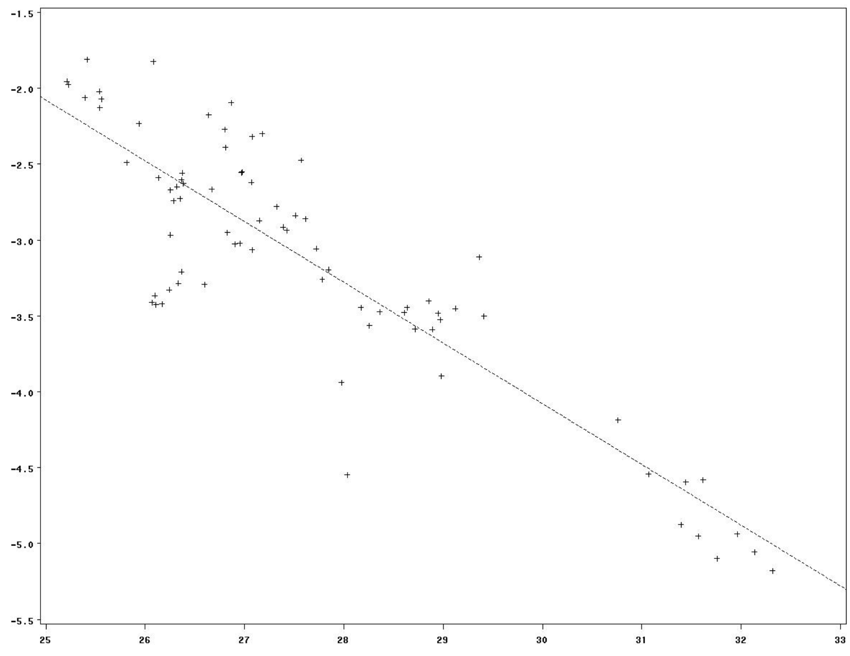
Figure 1. **Cost and volume of settlement instructions, 1993–2000**



Cost/value of deposited securities (log)

Number of settlement instructions (log)

Figure 2. **Cost and value of deposited securities, 1993–2000**



Cost/value of deposited securities (log)

Value of deposited securities (log)

4 Empirical evidence

The loglinear and translog cost functions estimates for each of the model specifications are reported in Tables 4–6. All parameter estimates associated with these estimates are reasonably consistent with the expectations. In most cases, the output and input specifications and binary variables turned out to be statistically significant. Importantly for such models, the R-squared and F-statistics exonerate the choice of output and input variables considered in this study.

The starting point of our analysis is a series of similar regressions using simple loglinear models (Ia–Id). All potential output variables (NSETT and VDEP) as well as a binary variable (ICSD) and proxy variables for technological progress are exclusively and jointly regressed on total cost variable.[3] These estimates perform quite well according to the model specification statistics. A sample of some of these estimates is reported in table 4. Based on the statistical considerations from the loglinear models, the evidence clearly shows that both variables (NSETT and VDEP) are relevant proxies for output and thus were selected for further analysis.

Several translog models are estimated using alternative input, output, and other specifications as given by equation 1. The outcome of these models is presented in Tables 5 and 6. A number of interesting observations can be derived from the tables. The translog specifications in models II and III have statistically significant second-order terms, justifying the use of these more flexible forms. The models IIb and IIIb are the preferred models because the t-statistics of the parameter estimates and the R-squared are somewhat higher compared to the other model specifications. In the single output case the evidence clearly indicates that processing a higher number of settlement instructions reduces costs for settlement institutions. Similar evidence on returns to scale are obtained when the second output variable (VDEP) is considered in models III. The dummy variable for ICSD businesses is highly statistically significant in all estimates with very much the same range of coefficients and sign. Consistent with simple cost ratio comparisons in Table 3, this finding may be interpreted that costs are three times higher if an institution initiates cross-border securities settlement operations. This reflects the fact that such institutions deal with a wider array of services, instruments, and different economic and legal environments requiring more complex and costly services and advanced system technologies.

[3] As mentioned above a dummy variable is included in order to control for the different institutional structure and business activities of those institions that settle securities on a cross-border basis. If costs of these institutions are included in the sample, the binary variable takes a value of unity and zero otherwise.

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

Explanatory variables	Coefficients	Model Ia Parameter estimates	Model Ib Parameter estimates	Model Ic Parameter estimates	Model Id Parameter estimates
Intercept	α_0	4.0878***	–1.7455***	–0.7885	0.3563
		(9.26)	(3.35)	(1.58)	(0.67)
NSETT	α_{Q1}	0.7189***		0.2410***	0.3703***
		(15.17)		(4.78)	(6.81)
VDEP	α_{Q2}		0.5998***	0.4468***	0.3411***
			(23.99)	(11.51)	(7.72)
ICSD	λ_1				1.2452***
					(4.22)
TIME	τ_1				–0.0347*
					(1.81)
R^2-adjusted		0.7510	0.8832	0.9096	0.9266
F-statistics		230.17***	575.56***	383.21***	240.91***
N		77	77	77	77

Note: Regressions are estimated using panel estimation on pooled settlement institution data for 1993–2000. All regressions are OLS estimates. The dependent variable represents total operating costs. All are log variables. T-values are reported in parenthesis. Superscripts ***, **, * indicate significance levels of 1%, 5%, and 10% respectively.

Once the translog cost functions are explicitly specified, we can derive parametric estimates of scale economies. Focusing further on the preferred models IIb and IIIb for the single- and multi-product case, we estimate scale elasticity at the sample median as well as at the mean. All results are reasonably similar in most estimates. We prefer the median estimates because when ranking the settlement institutions by the number of settled instructions, we find that the sample is skewed towards a few very big settlement institutions with a larger number of settled securities transactions. Therefore, we opt for median estimates as more representative over the mean estimates.

The scale elasticity estimates are obtained by taking the first partial derivative of the estimated translog model. The scale elasticity scores are then calculated by applying the estimated coefficients from Tables 5 and 6. Ray average cost (Baumol et al. (1988)) are computed by estimating a loglinear expansion path for the settlement institutions, lnVDEP = f(lnNSETT), on the sample data.[4] We repeat our estimates on sub-samples. The median number of settlement instructions processed in the system is selected next for each group as its representative

[4] The estimation results for the expansion path lnVDEP = f(lnNSETT) are reported in table A1 in the appendix.

output. Total value of deposited securities at this point is forecasted by using the outcome of expansion path estimation.

Table 5. **Translog cost regression parameters including single output, single input, and binary variables, 1993–2000**

		Model IIa	Model IIb	Model IIc
Explanatory variables	**Coefficients**	**Parameter estimates**	**Parameter estimates**	**Parameter estimates**
Intercept	α_0	70.758***	68.1059***	68.8940***
		(3.36)	(3.40)	(3.31)
NSETT	α_{Q1}	–2.6086	–2.0939	–2.2723
		(1.30)	(1.09)	(1.14)
NSETTSQ	β_{Q1Q1}	0.0419**	0.0449**	0.0437**
		(1.93)	(2.17)	(2.03)
GDPC	γ_{P1}	–10.7725***	–10.7234***	–10.7295***
		(4.18)	(4.36)	(4.21)
GDPCSQ	γ_{P1P1}	0.4504***	0.4740***	0.4644***
		(6.03)	(6.62)	(6.27)
GDPCNSETT	γ_{P1Q1}	0.2474	0.1936	0.2138
		(1.13)	(0.92)	(0.98)
ICSD	λ_1	2.7348***	2.8810***	2.8903***
		(11.94)	(12.85)	(12.32)
TIME	τ_1		–0.0514***	
			(2.85)	
YR94	δ_1			–0.0503
				(0.27)
YR95	δ_2			0.0626
				(0.36)
YR96	δ_3			–0.0375
				(0.22)
YR97	δ_4			–0.1664
				(1.02)
YR98	δ_5			–0.1616
				(0.98)
YR99	δ_6			–0.1914
				(1.11)
YR00	δ_7			–0.3535**
				(2.01)
R^2-adjusted		0.9303	0.9367	0.9334
F-statistics		170.07***	161.77***	82.89***
N		77	77	77

Note: Regressions are estimated using panel estimation on pooled settlement institution data for 1993–2000. All regressions are OLS estimates. The dependent variable represents total operating costs. All are log variables except of binary variables. T-values are reported in parenthesis. Superscripts ***, **, * indicate significance levels of 1%, 5%, and 10% respectively.

Table 6. **Translog cost regression parameters including multiple outputs, single input, and binary variables, 1993–2000**

Explanatory variables	Coefficients	Model IIIa Parameter estimates	Model IIIb Parameter estimates	Model IIIc Parameter estimates
Intercept	α_0	65.0174	91.1888	94.8119
		(0.91)	(1.34)	(1.35)
NSETT	α_{Q1}	–0.1498	0.9173	0.8946
		(0.03)	(0.20)	(0.18)
VDEP	α_{Q2}	–0.0569	–0.6864	–0.7150
		(0.02)	(0.20)	(0.20)
NSETTSQ	β_{Q1Q1}	–0.0732	–0.0393	–0.0339
		(0.76)	(0.43)	(0.36)
VDEPSQ	β_{Q2Q2}	–0.0561	–0.0660	–0.0687
		(0,68)	(0,84)	(0.84)
NSETT*VDEP	β_{Q1Q2}	0.1436	0.1277	0.1263
		(0.82)	(0.77)	(0.73)
GDPC	γ_{P1}	–11.8353	–16.8055*	–17.4758*
		(1.10)	(1.63)	(1.64)
GDPCSQ	γ_{P1P1}	0.5274	0.7205**	0.7399**
		(1.48)	(2.10)	(2.09)
GDPC*NSETT	δ_{P1Q1}	–0.0960	–0.2273	–0.2315
		(0.25)	(0.61)	(0.60)
GDPC*VDEP	δ_{P1Q2}	0.1227	0.2391	0.2546
		(0.41)	(0.84)	(0.87)
ICSD	λ_1	2.8095*	3.1596**	3.2389**
		(1.99)	(2.36)	(2.33)
TIME	τ_1		–0.0522***	
			(2.98)	
YR94	δ_1			–0.0633
				(0.37)
YR95	δ_2			–0.0131
				(0.08)
YR96	δ_3			–0.0521
				(0.34)
YR97	δ_4			–0.1689
				(1.11)
YR98	δ_5			–0.1484
				(0.97)
YR99	δ_6			–0.2504
				(1.55)
YR00	δ_7			–0.4008**
				(2.36)
R^2-adjusted		0.9408	0.9471	0.9441
F-statistics		121.84***	124.76***	76.48***
N		77	77	77

Note: Regressions are estimated using panel estimation on pooled settlement institution data for 1993–2000. All regressions are OLS estimates. The dependent variable represents total operating costs. All are log variables except of binary variables. T-values are reported in parenthesis. Superscripts ***, **, * indicate significance levels of 1%, 5%, and 10% respectively.

Table 7. **Decomposition of single- and multi-product scale economies in translog and loglinear model specifications according to size and geographical location**[1,2]

Panel A: Cost scale elasticities and economies of scale for single output and input case including trend and ICSD variable according to model IIb

Category	$\frac{\partial \ln TC}{\partial \ln Q_1}$ [3]	$\frac{\partial \ln TC}{\partial \ln Q_2}$ [4]	$\sum_i^n \frac{\partial \ln TC}{\partial \ln Q_i}$ [5]	$\frac{1}{\sum_i^n \frac{\partial \ln TC}{\partial \ln Q_i}}$ [6]
Q1	0.560	–	0.560	1.787
Q2	0.663	–	0.663	1.508
Q3	0.728	–	0.728	1.373
Q4	0.818	–	0.818	1.223
Median	0.696	–	0.696	1.437
Europe, Canada				
All	0.682	–	0.682	1.467
Excl. ICSD	0.639	–	0.639	1.565
ICSD	0.696	–	0.696	1.437
US	0.944	–	0.944	1.059
Asia, Pacific	0.741	–	0.741	1.350
Loglinear model median	0.744	–	0.744	1.344

1 Based on median number of settlement instructions processed in each group.

2 Estimated expansion path for settlement institutions lnVDEP = 10.9131 + 1.07 lnNSETT.

3 Scale elasticity coefficient of costs with respect to number of settlement instructions (equation 3.2).

4 Scale elasticity coefficients of costs with respect to value of deposited securities (equation 3.3).

5 Ray scale elasticity coefficient with respect to multiple outputs, NSETT and VDEP (equation 3.4).

6 Inverse of ε^c_{Ray}.

Table 7. (cont.) **Decomposition of single- and multi-product scale economies in translog and loglinear model specifications according to size and geographical location[1,2]**

Panel B: Cost scale elasticities and economies of scale for multiple output and single input case including trend and ICSD variable according to model IIIb

Category	$\frac{\partial \ln TC}{\partial \ln Q_1}$ [3]	$\frac{\partial \ln TC}{\partial \ln Q_2}$ [4]	$\sum_i^n \frac{\partial \ln TC}{\partial \ln Q_i}$ [5]	$\frac{1}{\sum_i^n \frac{\partial \ln TC}{\partial \ln Q_i}}$ [6]
Q1	0.497	0.144	0.640	1.562
Q2	0.513	0.185	0.698	1.433
Q3	0.555	0.175	0.730	1.370
Q4	0.613	0.162	0.775	1.291
Median	0.534	0.180	0.714	1.400
Europe, Canada				
All	0.525	0.182	0.707	1.414
Excl. ICSD	0.498	0.188	0.686	1.458
ICSD	0.534	0.180	0.714	1.400
US	0.694	0.143	0.837	1.194
Asia Pacific	0.563	0.173	0.736	1.358
Loglinear model median	0.413	0.306	0.718	1.392

7 Based on median number of settlement instructions processed in each group.

8 Estimated expansion path for settlement institutions lnVDEP = 10.9131 + 1.07 lnNSETT.

9 Scale elasticity coefficient of costs with respect to number of settlement instructions (equation 3.2).

10 Scale elasticity coefficients of costs with respect to value of deposited securities (equation 3.3).

11 Ray scale elasticity coefficient with respect to multiple outputs, NSETT and VDEP (equation 3.4).

12 Inverse of ε^{c}_{Ray}.

The scale elasticity coefficients with respect to the single- and multiple-output case as well as the Ray average cost (S) are reported in Table 7, panel A and B. The inverse of S is the scale elasticity of the combination of the two outputs. The median scale elasticity coefficient of the combined sample with respect to the number of settlement instructions processed in the system are 0.696 and 0.534 in panel A and B of table 7, respectively. In other words, cost would increase by almost 70% (53%) if the number of securities settled in the system is doubled. This means that there are significant scale economies involved in settlement operations. On the other hand, the elasticity coefficient is 0.180 with respect to the value of deposited securities, ie an increase in cost by 18% if value of deposited instructions is doubled. This demonstrates that overall economies of scale also exist to a large extent in depository activities. Moreover, evidence suggests that doubling both outputs pays off because costs would only increase by around 70%. A comparison of the results with the outcome of the estimated log linear model reveals almost identical results. For brevity, only the corresponding median estimates of the combined sample for the loglinear models are reported. Here, the doubling of settlement and depository businesses is associated only with 71% to 74% higher costs.

Analysing the data by geographical regions, we notice the existence of high economies of scale in European and Asia-Pacific subsample. For example, in the European subsample, domestic CSDs show highest potential of cost savings. The doubling of operations in CSD and ICSD systems would increase cost by 63.9% 69.6% (68.6% and 71.4%) in single (multiple) output case respectively. However, the experiences of the US system reveal a different picture. Indeed, the US settlement system suffer from substantially higher cost relative to other regions in processing twice of their outputs. For example, the cost will increase by 94% if the number of settlement instructions is doubled. Thus, the centralised US system operates at an almost optimal scale and acts as a cost benchmark meaning that the doubling of activities does not improve cost effectiveness.

In order to gain further insights into economies of scale in the settlement industry, we estimate cost elasticities for four different size categories based on the median number of settlement instructions. Clearly, significant economies of scale exist for smaller systems, independently of the number of outputs considered. The cost of processing twice the number of settlement instructions is 56% among the smallest institutions. Economies of scale also exist among the largest settlement institutions, although the extent of savings in unit cost is relatively low. The doubling of the number of settlement instructions for the largest settlement agencies implies cost increase of around 80%, depending on the model specification.

According to our findings, the smaller settlement service providers can exploit high potential economies of scale. This may result in average or unit cost reductions as the level of output increases per time period. Importantly, in the presence of such economies of scale, smaller settlement institutions may be well advised to accelerate investment plans, reduce prices, and thereby rising overall production at lower unit cost than if scale economies were absent. These findings also bear important implications for the competitive structure of the settlement industry. It can be inferred that mergers/alliances especially of smaller institutions may be cost advantageous. It might be optimal for smaller settlement service providers to form implicit mergers in order to process more settlement business through a less number of systems. Thereby, cost may be spread over a wider number of transactions and settlement services could be provided at lower cost. Moreover, our findings suggest that greater integration of different systems would allow settlement service providers in the European area and Asia-Pacific region to directly benefit from economies of scale. Accordingly, the rule of thumb of "two-thirds" applies in the settlement industry that costs should increase by about 65%–70% as output or potential volume doubles. The centralised US appears to serve as the cost saving benchmark. However, when interpreting the results one should bear in mind that it is unlikely that the centralised US model could be successfully implemented in the EU at least in the short and medium run given a plethora of integration barriers, including national differences in information technologies and interfaces, taxation, legal certainty, cultures, etc.[5]

Table 8. **Scale economies and technological progress**

$-\frac{\partial TC}{\partial t}$	**Model IIb** [1 output, input, trend, ICSD]	**Model IIIb** [2 output, input, trend, ICSD]	**Total average**
Translog	–0.0514	–0.0522	–0.0518
Loglinear	–0.0380	–0.0376	–0.0378
Total average	–0.0447	–0.0449	–0.0448

As discussed in section 3, we are also interested in seeing whether the influence of technology related initiatives and expenses generated cost savings over time. We estimate the influence of technological progress indirectly by including the time trend term (T) in the loglinear and translog model specifications. Differentiating the cost function with respect to T and taking it with the negative sign yields a measure of technical progress. The derived estimates reported in Table 8 suggest that settlement institutions were able to become more cost effective over time at an average yearly rate of 4.5% of cost reduction, made possible by the intensive use and investment in new technologies and system updates. Strikingly similar results are obtained by alternatively controlling for time when dummy variables for each year enter the estimations according to the models IIc and IIIc. The estimates reveal negative coefficient signs for all yearly variables suggesting yearly cost reductions due to technological progress. The only exception is in 1995 where operating cost of the settlement institutions rose by the rate of 6.3%, possibly reflecting intensive investments in upgrading settlement system technologies. In later years, these investments seem to pay off in helping settlement institutions becoming more cost effective as evidence indicates a statistically significant and peak annual cost reduction by 16.21% from 1999 to 2000. These findings are consistent with the academic literature (Litan and Rivlin (2001)), where significant savings were generated by the productive use and

[5] Consult Giovannini Group (2002) for a more detailed discussion on barriers to efficient cross-border clearing and settlement in the EU.

implementation of technology. Additionally, recent research on the stock exchange industry report comparable results of productivity improvements over time due to technological change and money spend on new technologies (Hasan, Malkamäki, and Schmiedel (2002), Schmiedel (2002)).

Table 9. **Relative efficiency of individual settlement institutions**

Code	Model IIb [1 output, 1 input, trend, ICSD]	Code	Model IIIb [2 output, 1 input, trend, ICSD]
CRE	–0.3068	NEC	–0.2936
JAS	–0.2943	CRE	–0.2769
NEC	–0.2807	MON	–0.1893
MON	–0.2117	VP	–0.1552
VPS	–0.1500	SEG	–0.0777
VP	–0.1440	DTC	–0.0419
CDS	–0.0060	VPS	–0.0085
ECB	0.0000	ECB	0.0000
CED	0.0141	CED	0.0112
DTC	0.0272	CDS	0.0228
HSC	0.1014	JAS	0.0744
SEG	0.1473	VPC	0.0974
VPC	0.1894	DBC	0.1958
DBC	0.2589	HSC	0.2071
SIC	0.3102	SIC	0.2150
APK	0.4658	APK	0.5372

Note: The coefficients reported in this table are calculated as residuals from the models including outputs, input, and binary variables. The scores are listed in descending order according to the relative efficiency levels of the individual settlement institutions.

It is also useful to analyse the relative operative efficiency of settlement institutions. Table 9 provides preliminary analysis based on the results shown in Table 7. Residuals of our preferred models provide indicative information on the efficiency of the individual settlement service providers. One should note that the log of the residuals provides us only with information on the deviations from the estimated average cost performance. This information does not take returns to scale into account meaning that it is only possible to compare settlement institutions that are of the same size. A more detailed picture could be obtained by carrying out efficient frontier analysis, which is beyond the scope of this paper. However, in spite of the limitations of the analysis, it documents that settlement service providers of equal size seem to experience extreme differences in efficiency. Especially, this should raise concerns for the service providers that are ranked at the bottom of the table. Owners of the SICOVAM have actually undertaken important steps in order to improve overall efficiency as evidenced by the initiative to integrate and carry out settlement businesses as a wholly-owned subsidiary of the Euroclear Group.

5 Conclusions

This paper examines economies of scale in the depository and settlement industry. The key intention of this paper is to inquire whether there is any potential cost saving from expanding depository and settlement businesses with special perspectives from experiences of settlement institutions by regions of the world, by size and scope of settlement services. The paper investigates the existence and extent of economies of scale among settlement institutions using loglinear and translog cost functions. As acknowledged in Giovannini Group (2002), the importance for such analysis derives from the fact that the removal of cost inefficiencies in clearing and settlement is a necessary condition for the development of a large and efficient financial infrastructure, in particular for the European context.

The overall results of this study reveal the existence of substantial economies of scale related to both depository and settlement activities. On average, the centralised US system is found to be the most cost effective settlement system and may act as the cost saving benchmark. However, settlement institutions from Europe and Asia-Pacific regions show highest potential in unit cost savings. Similar results were found for relatively smaller service providers where a doubling of settlement and depository activities would increase cost by 2/3. The findings also suggest that operating costs for carrying out cross-border settlement appear to be much higher than operating a domestic CSD reflecting the current complexities of EU international securities settlement and differences in the underlying scope of ICSD services. Moreover, the evidence indicates that operating cost decreased continuously over time, possibly due to investments in implementing new systems or upgrading settlement technology.

The results clearly support the formation of mergers and alliances among smaller settlement institutions. In other words, expansions or pooling of depository and settlement businesses is likely to enhance savings in unit cost for small and medium sized institutions. This effect tends to be less pronounced for bigger service providers. Therefore, smaller institutions may be well advised to accelerate investment plans, reduce prices, or form implicit mergers, thereby achieving higher production at lower unit cost in their depository and settlement businesses.

Our results also suggest that regulation matters a lot for the effectiveness of the operative infrastructure in the settlement industry. We find that in the regulated and centralised US market settlement is carried out at almost optimal scale compared to the corresponding systems in Europe and Asia-Pacific regions. However, it is strongly questionable to what extent a US style model can successfully be implemented in the EU at least in the short and medium run given a plethora of integration barriers in the EU. At current state a possible outcome of further integration of the settlement infrastructure in the European area is likely to be some kind of collaboration or consolidation of existing CSDs, while totally new infrastructure solutions could be more feasible in other markets.

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Appendix 1

Table A1. **Linear logarithmic expansion path estimation**

Explanatory variables	**Coefficients**	**Parameter estimates**
Dependent variable	VDEP	
Intercept	α_0	10.913***
		(13.80)
NSETT	α_{Q1}	1.070***
		(12.59)
R^2-adjusted		0.6745
F-statistics		158.48***
N		77

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