"MEASURING SCALE ECONOMIES IN A HETEROGENEOUS INDUSTRY: THE CASE OF EUROPEAN SETTLEMENT INSTITUTIONS"

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MEASURING SCALE ECONOMIES IN A HETEROGENEOUS INDUSTRY: THE CASE OF EUROPEAN SETTLEMENT INSTITUTIONS[*]

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Abstract

We examine whether the European settlement institutions are technically efficient. This is done by means of estimating a translog cost function, and investigating whether scale economies are fully exploited. Since the sample is quite heterogeneous, fixed effects regression is introduced. From the results obtained, there clearly are economies of scale in this industry throughout all output ranges. This implies that further consolidation in this industry probably is ahead.

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1. Introduction

Nowadays, the securities settlement and safekeeping industry is subject to much debate. More in particular, the discussion concerns the way in which the industry should be organised in the future. Compared to the American market, the European one still is quite fragmented. Basically, there was one central securities depository (CSD) institution in each country that would also offer settlement services for domestic securities. Only recently some cross-border CSDs consolidation has taken place, but several national institutions continue to co-exist, mainly due to the existence of different systems, legal procedures, fiscal regimes, etc. This fragmentation might give rise to additional costs and risks, and therefore a reduction of the number of settlement and safekeeping institutions might be welfare increasing.

More in particular, the issue is whether consolidation should be encouraged, and if so, what kind of consolidation is preferable. In Europe, two consolidation trends can be observed. These trends are shown in figure 1.

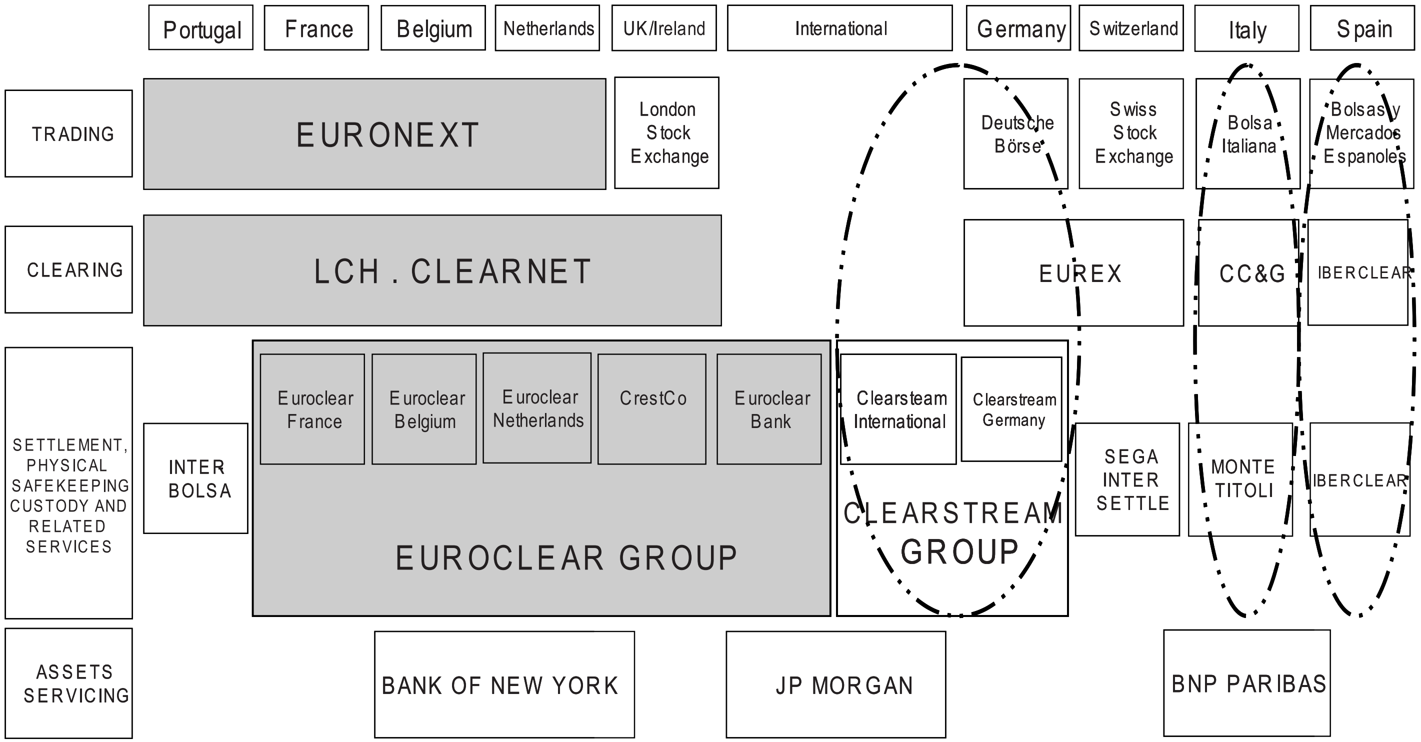
First, there was a vertical consolidation movement. Here, the institutions that are active in the trading, clearing, settlement and safekeeping process have been integrated into one single institution. An example of this structure, which is sometimes called a vertical silo, is Deutsche Börse, which incorporates the trading platform, the clearing institution (Eurex Clearing) and the settlement and safekeeping institution (Clearstream) into one holding.

The second type of consolidation that has taken place was horizontal, implying a cross-border integration and cooperation between institutions that provide similar services and products. An example of this is Euronext at the level of securities trading, and Euroclear at the level of settlement and safekeeping. The first is a merger of the French, Belgian, Dutch and Portuguese stock exchanges, while the latter acts as a Central Securities Depository (CSD) for France, Belgium, UK, Ireland and the Netherlands.

Efficiency

Further consolidation in this industry might give rise to higher efficiency and lower operating costs. The present contribution investigates whether this reduction in operating costs is feasible, and whether the current structure of

Figure 1: Consoliation Trends in Europe



the industry is efficient or not. In the last case, further consolidation is to be expected.

Consolidation in this industry however raises many questions regarding competition, that is allocative efficiency. For example, exchanges and CSDs work together very tightly. More in particular, all trades that are concluded at an exchange are settled most of the time by only one CSD. This implies that, in order to be able to trade, all members of an exchange need either a securities account with the CSD or to appoint an agent bank that has an account with the CSD. These holdings therefore occur directly or through an intermediary. Whenever two members of an exchange want to respectively buy and sell, the CSD receives automatically (often through a central counterparty that will perform clearing and netting activities) an instruction to debit the securities account of the seller and to credit the buyer's securities account. This process is called straight through processing. Of course, over time, this relation between the exchange and the CSD can change, and depending on the magnitude of the switching costs could lead to alternating arrangements. In a theoretical paper, Tapking and Yang (2004) conclude that, under certain assumptions, a horizontal integration of CSDs lead to a higher welfare than a vertical integration of exchanges and CSDs, while the vertical integration seems to provide a higher welfare than a completely separated industry configuration.

Also Van Cayseele (2005) comes to the conclusion that further horizontal consolidation of the European clearing and settlement industry should be encouraged. He introduces the two-sidedness of the market by investigating a model of platform competition in the spirit of Rochet and Tirole (2003), and shows that both investors and issuers gain from consolidation. Finally, Köppl and Monnet (2004) use mechanism design to investigate the incentives for further consolidation. Clearly then most, if not all, of the results of economic modelling favour further horizontal consolidation. But whether technical efficiency gains will reinforce this conclusion is a different question, which only can be answered by empirical analysis.

Schmiedel, Malkamäki and Tarkka (2002) provide an empirical analysis of the industry by estimating a cost function. However, as will be discussed in section 3, they obtain some remarkable results. For one thing, the estimates of the coefficients of the translog cost function specification come with the signs opposite of the ones expected (this would for example lead to the counterintuitive conclusion that total costs decrease when output is increased), although they are often not statistically significant. By applying

OLS estimation to a panel data set, Schmiedel et al. do not exploit "between" and "within" variation in the observations as a source of differences in decision making of the players in the sample. In the present contribution, we investigate the possibilities of taking into account the information that an observation has been generated by a particular CSD rather than by another, by applying fixed effects regression to the problem.

Safety

It should also be noted that in order to guide policy making, it is not sufficient to look at efficiency alone. One should also take into consideration the safety of the settlement procedure. As discussed in the Bank of International Settlements report (1992), the so-called "Delivery versus Payment" procedure is preferred when trades are settled. This procedure ensures that securities are transferred if and only if payment occurs. In this way, the principal risk, which is the risk that the seller of a security delivers a security but does not receive payment or that the buyer of a security makes payment but does not receive the security, is avoided. This risk is the largest source of credit risk in securities settlement.

Delivery versus Payment does not eliminate other sources of risk which are the replacement cost risk and the liquidity risk. The former is the risk that a counterparty to an outstanding transaction for completion at a future date will fail to perform on the settlement date. The latter implies that a counterparty will not settle an obligation for full value when due, but on some unspecified date thereafter. It could be expected that when consolidation takes place, these risks can be reduced because given the size of these institutions these kind of defaults are less likely to take place and may be internalised to a further extent.

Besides academic interest, the clearing and settlement industry also has attracted the attention of policy makers, notably the European Commission. In the "Communication to the Council and the European Parliament" (2004), the Commission states that an integrated and efficient capital market is essential for Europe. A crucial element in this process is the safety and efficiency of the procedures that occur to finalise a security transaction. The Commission argues that the clearing and settlement process is therefore fundamental for the proper functioning of securities markets. In this Communication, the Commission also proposes some actions it wants to take in order to improve the clearing and settlement arrangements and to tackle the barriers that are identified by the Giovannini reports (2001, 2003).

The Committee on Payment and Settlement Systems (CPSS) together with the Technical Committee of the International Organization of Securities Commissions (IOSCO) make in their Consultative Report (2001) a number of recommendations for securities settlement systems. One of these recommendations concerns efficiency. It states that: *"while maintaining safe and secure operations, securities settlement systems should be cost effective in meeting the requirements of the users"* (Recommendation 15, p.20).

Also, the report argues that when the efficiency of settlement systems is considered: *"the needs of the users and the costs imposed to them must be carefully balanced with the requirement that the system meets appropriate standards of safety and security"*. For instance, if a system is inefficient, this might give rise to distortion on financial markets, while an unsafe settlement system will not attract any participants. Therefore, efficiency of securities settlement is an important issue, but a stable and safe environment is also required. Regarding the latter, there might be a role for the regulatory authorities. They could impose the standards to which every institution has to comply. In this way, safety and stability can be enhanced, for instance by setting deposit insurance and reserve requirements. A high level of these requirements can however be inefficient, and thus the institutions incur additional costs in complying with these regulations. The institutions in turn then might pass these additional costs on to their customers, resulting in higher fees. Therefore, a trade-off between safety and efficiency needs to be made. Currently, various forms of taxes or regulation continue to co-exist in the European Union, which again possibly and plausibly increase operating costs.

CPSS has also published some reports with respect to payment systems. A first one (2001) discusses the core principles for important payment systems. It states that a well functioning payment system is essential for a financial system to work appropriately. Therefore, 10 core principles to which a payment system should comply are formulated. Another report (2005) discusses some new developments in large-value payment systems. Clearly, since new or enhanced features make the technical infrastructure of these payments systems much more complex and the analysis of risks and efficiency more difficult, these evolutions make investments in infrastructure inevitable, and as a result, technical innovation will have a effect on operating costs, and thus on the cost function.

The remainder of the present contribution is organised as follows. In the next section, a brief discussion is given of what clearing, settlement and safekeeping involves. Thereafter, a short overview of the existing literature is given. In the fourth section, we explain the econometric approach that will be followed, while in section 5 the data that are used are discussed. The empirical results are given in section 6. Finally, section 7 concludes.

2. The European clearing, settlement and safekeeping industry

In the literature, a lot of attention has been paid to the way in which trades at an exchange are realised. However, little attention has been given to the processes that occur after the completion of a trade. Before we proceed, it might therefore be useful to explain what the processes performed by the institutions in the clearing, settlement and safekeeping industry exactly are.

After a trade has been realised, basically three processes occur. The first one is the clearing process. In the clearing stage, the obligations of the buyer and the seller are determined. When trading is effected, sellers have the obligation of delivering securities and the right of receiving cash, and buyers have the obligation of paying cash and the right of receiving securities. The transactions in financial markets can be cleared by a number of institutions, for instance by a clearinghouse.

A clearinghouse is a central location or central processing mechanism through which financial institutions agree to exchange payment instructions or other financial obligations, such as securities obligations generated by trading on an exchange. Clearing can occur either on gross or on net positions. If the latter is the case, a process of netting takes place. This is an agreed offsetting of positions or obligations by trading partners or participants. The netting reduces a large number of individual positions or obligations to a smaller number of positions or obligations. More in particular, all gross positions are offset against each other so that all outstanding positions in one given security are converted to a single debit or credit.

It is also possible to trade with a central counterparty, which imposes itself in between the buyer and the seller (novation). In this way, the different parties remain anonymous to each other, and the parties don't have to worry about the credit risk of the respective counterparty. The IOSCO report (2004) contains a number of recommendations with respect to central counterparties. Given the large and growing role of these intermediaries in securities settlement systems, the *"central counterparties should be cost-effective in meeting the requirements of participants while maintaining safe and secure operations"* (Recommendation 12, p.43). However, as argued in the report, an assessment of the efficiency of these counterparties is very difficult, because of among other things the low level of competition and the possible existence of barriers to entry. A more comprehensive discussion of this problem can be found in the CPSS report.

The focus of the present contribution however is on the next two processes, namely settlement and safekeeping. During the settlement process, a transfer of money is made from the buyer to the seller, while the delivery of the securities goes in the opposite direction. Since most of the securities are dematerialised nowadays, this delivery of money and securities is done through book-entries instead of through physical delivery. The delivery is typically executed by a Central Securities Depository (CSD) or an International Central Securities Depository (ICSD), although local agent banks can settle trades internally when a trade takes place between investors who happen to use the same local agent bank. The main difference between a CSD and an ICSD is that the latter acts as issuer-CSD (central depository) for international securities, while the former is the issuer-CSD for domestic securities.

In the past, there was one CSD for each country. Recently, however, some horizontal consolidation has taken place. Examples are Euroclear, which now acts as the CSD for France, Belgium, the Netherlands and the United Kingdom, and Nordic Central Securities Depository, which was established at the end of 2004 as a consolidation between the Swedish and Finnish CSD.

The last process is the so-called safekeeping of securities. When the stock of a company has been sold from investor A to investor B, B now holds a claim on this company, while A does not hold one anymore. So the positions of both A and B have changed. Both investors might also hold positions in stocks of other companies in which they do not trade. So it is necessary to keep track of all positions at each point in time, so as to enable a company to interact with the entire group of its shareholders. This service is called custody and concerns the safekeeping of the physical securities as well as the administration on behalf of companies and investors (sometimes also called assets servicing). Custody entails more than just keeping record of positions. Sometimes assets needs to be serviced, for instance in the case of dividend payments, stock splits, the emission of additional shares, etc. Often the custody service is provided by the same institutions that also do the settlement, namely the CSDs, ICSDs or any intermediary along the holding chain. One can wonder whether this constitution should remain as it is, and some have argued that in the case of CSDs and ICSDs it is preferable that the settlement and safekeeping activities are separated. Based upon econometric analysis, we will among other things try to find an answer to this issue.

It can be argued that institutions that combine settlement and safekeeping basically combine a two-sided network with a one-sided network, in the sense of Economides and White (1994). Settlement is a two-sided network, since the only way in which a transaction can be realised is by interaction between the settlement institution and the investor on the one hand, and between the investor and the settlement institution on the other. Asset servicing on the other hand is a one-sided network, because a product involves the interaction of two different parties, viz. an issuer and an investor – for instance, when a company gives the CSD an instruction to pay a dividend. Van Cayseele and Wuyts (2005) provide a more detailed explanation on this issue. They argue that a combination of the two types of networks might lead to increased efficiency and network externalities. However, whether this is the case has to be investigated empirically.

3. Review of the literature

The literature survey can be short, since up to now little empirical research has been done regarding the organisation of the European settlement and safekeeping industry. Before dealing with the scarce contributions, it should be noted that there are some papers that set up a theoretical model in order to find an indication of the future structure of the industry, see for instance Van Cayseele (2005), Tapking and Yang (2004), Rochet (2005), Holthausen and Tapking (2004) and Kauko (2005). From a policy perspective, the Committee on Payment and Settlement Systems (CPSS) has written a number of extensive reports concerning payments systems (2001, 2005), while CPSS together with the Technical Committee of the International Organization of Securities Commissions (IOSCO) have made a number of recommendations for securities settlement systems (2001). Also, the European Commission (2004) has proposed a number of measures and policies in order to improve clearing and settlement arrangements.

Currently, only two empirical papers have been written with respect to this industry. The seminal empirical paper was written by Schmiedel, Malkamäki and Tarkka (2002). They estimate a translog cost function to examine whether or not economies of scale are present in this industry. To capture output, they use the number of securities settled as a proxy for the settlement services provided by a CSD, while the safekeeping service is approximated by the value of securities deposited in the system. As an input price, they use GDP per capita of the country in which the CSD is active. The results obtained are remarkable. More in particular, the estimated coefficients of the output variables have a negative sign, which implies that total costs decrease as output increases. Such results are at odds with received microeconomic theory. The input price variable also has a negative sign. In addition, estimates are very insignificant, so it is hard to draw any conclusions at all. Nevertheless, based upon their results, they indicate that economies of scale are present in this industry, especially for the smaller institutions.

Van Cayseele and Wuyts (2005) attack the problems that emerged in the work by Schmiedel et al. by using alternative output variables and input prices. As output variables, they use the number of clients of a CSD to capture the settlement service, while the number of securities held is used as a measure of safekeeping. As argued above, this is closer to economic modelling of the industry. Russo et al. (2004) already indicate that the account management and hence the number of accounts is related to the safekeeping activities of settlement institutions.

As input prices, the price for labour is seen to equal the labour bill divided by the number of employees, and the ratio of GDP relative to a fixed base year is used to get a price indication of other inputs used in the settlement and safekeeping process. Van Cayseele and Wuyts also estimate a translog cost function, and obtain that total operating expenses of the CSDs increase with both output variables, of which one is highly significant. Moreover, they find evidence that large economies of scale exist with respect to the output variables. Van Cayseele and Wuyts also examine whether economies of scope are present. More in particular, they investigate whether the joint production of settlement and safekeeping gives rise to efficiency gains. Since the translog cost function is not stable to verify this property (see Röller (1990a) and Röller (1990b)), they estimate a constant elasticity of substitution – quadratic (or CES-Q) cost function. The results indicate that the separation of settlement and safekeeping activities causes a cost increase for the institutions.

Another important remark that needs to be made is the fact that CSDs are very heterogeneous. First of all, they perform the settlement and safekeeping activities on quite a different scale. This can be seen below when the descriptive statistics of the sample are discussed (see table 2). Moreover, the CSDs might execute the before mentioned activities in a different way. Thus, their technologies may differ, for instance because of a different legal and institutional framework. This implies that their production function might not be exactly the same. This can be seen from figure 2, where the ICSDs are clearly on a different average cost curve. To control for this sample heterogeneity, it is possible to apply a fixed effects regression, since adding dummies and then apply OLS is not best econometric practice.

In the fixed effects model the firm-specific effects are estimated as constant numbers. More in particular, the differences across institutions are captured in differences in the constant term. It might be that these constant terms are correlated with the exogenous variables. As is well known in the literature, the fixed effects estimators are not influenced by heterogeneity bias. A more detailed description of this estimation technique is provided in section 4.2.2.

4. The model

4.1. Variables

To measure output, Schmiedel et al. use the number of securities settled in the system to approximate the settlement services of the institutions, while the value of securities held is used as a proxy for the safekeeping activities. As an input price, they use the gross domestic product (GDP) per capita. They explain the use of this variable by the fact that this variable proxies the differences in labour costs across countries. However, as argued in Van Cayseele and Wuyts, this is a quite general measure to approximate the input prices, and there might be a multicollinearity problem between the output variables and this input price. More specifically, when stock markets boom, stock valuations increase. This implies that value of the holdings by the investors increase as well. As a result, they will be able to consume more, and this might have a Pigou-effect on GDP. On the other hand, an increase in GDP could be caused by a shift in trend growth, thus leading to increased sales and profits. Since share prices depend on the expected future profits of the companies, they can be assumed to increase as GDP increases. As a result, the valuation of the securities held will go up with GDP.

To avoid this multicollinearity problem, it is possible to use alternative input and/or output variables. In this paper, we investigate to what extent the problems encountered by Schmiedel et al. can be remedied, without using alternative output variables.

As a dependent variable, Schmiedel et al. use the total operating expenses, which consist of depreciation, labour costs and the so-called "other costs". They also include a dummy to indicate whether an institution is an ICSD or not.

In the empirical part of this paper, we will use the total operating expenses including depreciation as well as a measure of the costs made by the institutions that are active in the settlement and safekeeping industry. This variable will be denoted by TC.

Concerning the output variables, the same variables as in Schmiedel et al. are used. More in particular, the number of transactions settled is used and referred to as Transet. The value of securities held is used as a proxy for the safekeeping activities of the institutions, and denoted as VHold.

As input variables, we will use the GDP per capita (GDPcap) to reproduce the results obtained by Schmiedel. et al. However, in order to avoid the above mentioned problem of multicollinearity, an alternative specification will be used in which two input variables are included, namely labour costs (Lc) and other costs (Oc). As in Van Cayseele and Wuyts, these two input prices will be approximated by the labour price, again calculated as the total labour costs divided by the number of employees, and the ratio of GDP relative to a fixed base year.

4.2. The translog cost function

4.2.1.Model specification

The following general form will be used for the cost function

$$\ln(TC) = f[\ln(Transet), \ln(VHold); \ln(Lc), \ln(Oc)] \quad (1)$$

This implies that total costs depend on the magnitude of the outputs, namely the number of transactions settled (Transet) and the value of securities held in safekeeping (VHold), and on input prices, being labour costs (Lc) and other costs (Oc).

The cost function is specified as a translog cost function, see Christensen, Jorgensen and Lau (1973). The logarithm of the total costs is approximated by a second order Taylor expansion in the logarithms of outputs and input prices. It is also possible to include other variables like time, but this variable is not included in the model we specified. This type of cost function is often used to analyse the cost structure of the banking industry.

Christensen et al. estimated the translog specification on data from regulated US electricity producers, who have an obligation to supply. In settlement and safekeeping, the number of settlements essentially is driven by activity on the stock exchanges, while the value of deposits depends on asset pricing. Neither the first nor the second is an output proxy that will be strongly affected by decision making of management of the CSD. Reiss and Wolak (2005) question the validity of regressions of costs on output in such environments, and propose a specification which has the causality the other way around: management decides on a budget (total costs) which explains the output volume that can be reached. However, such an approach does not make sense in a multiproduct environment. Moreover, in order to be able to compare our estimation results with those of Schmiedel et al., it is necessary to continue to use these output variables when the cost function is estimated.

More specifically, the following specification of the translog cost function will be estimated[3]:

$$\begin{aligned}
\ln(TC) = {} & c + \alpha_1 \ln(Transet) + \alpha_2 \ln(VHold) + \left(\frac{1}{2}\right)\beta_{11}\left[\ln(Transet)\right]^2 \\
& + \left(\frac{1}{2}\right)\beta_{22}\left[\ln(VHold)\right]^2 + \beta_{12}\ln(Transet)\ln(VHold) \\
& + \gamma_1 \ln(Lc) + \gamma_2 \ln(Oc) + \left(\frac{1}{2}\right)\delta_{11}\left[\ln(Lc)\right]^2 + \left(\frac{1}{2}\right)\delta_{22}\left[\ln(Oc)\right]^2 \\
& + \delta_{12}\ln(Lc)\ln(Oc) + \lambda_{11}\ln(Transet)\ln(Lc) \\
& + \lambda_{12}\ln(Transet)\ln(Oc) + \lambda_{21}\ln(VHold)\ln(Lc) \\
& + \lambda_{22}\ln(VHold)\ln(Oc) + \mu_1 ICSD + \varepsilon
\end{aligned} \tag{2}$$

whereby ICSD is a dummy variable to indicate whether an institution is an ICSD or not, and ε is the error term, here assumed to be efficiency shocks observed by the decision maker but unknown to the econometrician.

It is possible to add factor share equations to the cost function in (2). They are obtained by relying on duality theory and applying Shephard's lemma to the translog cost function. More in particular, the following share equations hold:

$$\begin{aligned}
S_{Lc} &= \frac{\partial \ln(TC)}{\partial \ln(Lc)} \\
&= \gamma_1 + \delta_{11}\ln(Lc) + \delta_{12}\ln(Oc) + \lambda_{11}\ln(Transet) + \lambda_{21}\ln(VHold)
\end{aligned}$$

$$\begin{aligned}
S_{Oc} &= \frac{\partial \ln(TC)}{\partial \ln(Oc)} \\
&= \gamma_2 + \delta_{22}\ln(Oc) + \delta_{12}\ln(Lc) + \lambda_{12}\ln(Transet) + \lambda_{22}\ln(VHold)
\end{aligned} \tag{3}$$

In the share equations in (3), S_{Lc} and S_{Oc} reflect the share the input variables labour costs and other costs have in the total operating expenses.

[3] We assume, without loss of generality, that the coefficients of the interaction terms are symmetric ($\beta_{12} = \beta_{21}$ and $\delta_{12} = \delta_{21}$). We will only use β_{12} and δ_{12} in the remainder of this paper.

It is possible to estimate the translog cost function in equation (2) by OLS or by means of the random effects technique. When the share equations in (3) are added to the system, the cost function in (2) is estimated jointly with the share equations in (3). This is done by applying the Seemingly Unrelated Regression technique. As an alternative, one uses the fixed effects estimator for the translog cost function in (2) to deal with the problem of sample heterogeneity.

4.2.2. The fixed effects model

To estimate on panel data, fixed effects regressors are used. This is actually merely a linear regression model in which the intercept terms vary over the individual units. In this way, the individual heterogeneity is treated as N parameters that are to be estimated. More in particular, the model that is estimated has the following form.

$$y_{it} = \alpha_i + \beta x_{it} + \varepsilon_{it} \tag{4}$$

where i = 1, ..., N denotes the individuals (or the different institutions in our case) and t = 1, ..., T denotes the number of time periods. The variable α_i is actually a set of N dummy variables and can be written as $\alpha_i = \sum_{j=1}^{N} \alpha_j d_{ij}$, where $d_{ij} = 1$ if $i = j$ and 0 elsewhere. Basically, a set of N dummy variables is included in the model. The parameters can be estimated by ordinary least squares (OLS), and the implied estimator for β is called the least squares dummy variable estimator. The model in (4) can be seen as a more general description of the translog cost function in (2) in which the dependent variable is written as y_{it} and the output variables, input prices and all interaction terms are included in the matrix x_{it}.

It is however not very attractive to have a regression model with so many variables. Therefore, a transformation can be made. More specifically, exactly the same estimator for β is obtained if the model is estimated in deviations from the individual means. This implies that the individual effects α_i are eliminated. To do this, the T observations for each individual can be averaged:

$$\bar{y}_i = \alpha_i + \beta \bar{x}_i + \bar{\varepsilon}_i \tag{5}$$

where $y_i = \frac{1}{T} \sum_t y_{it}$, and similarly for the other variables. Then, by combining equations (4) and (5), it is possible to write:

$$y_{it} - \bar{y}_i = \beta(x_{it} - \bar{x}_i) + (\varepsilon_{it} - \bar{\varepsilon}_i) \qquad (6)$$

The transformation that produces observations in deviation from individual means, like in equation (6), is called the within transformation. The OLS estimator for β that is obtained from this transformed model is defined as the fixed effects estimator. The parameter estimates are exactly identical to the least squares dummy variable estimator that was mentioned previously. The individual effects can be estimated by applying the estimations for β to equation (5).

Another possibility for the estimation of panel data is the random effects model. In the fixed effects model, the individual effects are not of any interest. The panel data model in equation (4) can however be rewritten in the following way:

$$y_{it} = \mu + \beta x_{it} + (\alpha_i - \mu) + \varepsilon_{it} \qquad (7)$$

where $\mu = \frac{1}{N}\sum \alpha_i$, which implies that this is the average individual effect. From equation (7) a new error term can be defined, namely $u_{it} = (\alpha_i - \mu) + \varepsilon_{it}$. So the error term now consists of two components, namely an individual specific and permanent component $(\alpha_i - \mu)$ that does not vary over time, and a remainder transitory component ε_{it} that does vary over time and is assumed to be uncorrelated over time. It can be proven that the estimation of the model in equation (7) by means of OLS is inefficient and yields incorrect standard errors. The random effects model can however be estimated efficiently by generalised least squares (GLS). Again then, a transformation needs to be done. For a more extensive description, see for instance Verbeek (2000) and Hsiao (1996).

Whether the fixed effects model or the random effects model is the most appropriate needs to be determined. The fixed effects model considers the distribution of y_{it} given α_i, and the latter can be estimated. This is suitable if the individuals in the sample can be viewed as "unique", and thus can not be seen as drawn randomly from an underlying population. The fixed effects technique is thus the most appropriate when countries, companies or industries are considered. Since the sample that is used in this paper consists of institutions that are active in the clearing and settlement industry, this is already a first indication to estimate the translog cost function in equation (2) by means of the fixed effects model.

A more formal indication can be derived from the application of the Hausman test. This test compares the estimates from the fixed effects and the random effects model. The null hypothesis is that the model is a random effects model, which implies that α_i and x_{it} are uncorrelated. The alternative hypothesis says that the model is a fixed effects model, and thus it is possible that α_i and x_{it} are correlated. One estimator, namely the fixed effects estimator, is consistent under both the null and the alternative hypothesis, while the other estimator, being the random effects estimator, is consistent only under the null hypothesis[4]. The Hausman test statistic has the following form:

$$\xi_h = \left(\hat{\beta}_{FE} - \hat{\beta}_{RE}\right)' \left[\hat{V}\left\{\hat{\beta}_{FE}\right\} - \hat{V}\left\{\hat{\beta}_{RE}\right\}\right]^{-1} \left(\hat{\beta}_{FE} - \hat{\beta}_{RE}\right) \tag{8}$$

where $\hat{\beta}_{FE}$ and $\hat{\beta}_{RE}$ denote the estimations from the fixed effects and the random effects model respectively, and $\hat{V}$ denote estimates of the covariance matrix. Under the null hypothesis, the test statistic in (8) has an asymptotic Chi-squared distribution with K degrees of freedom, with K the number of elements in β.

With the Hausman test statistic, we have an objective way to determine which estimation technique should be used. In the empirical part of this paper, we will use this technique to examine which estimation technique should be used to estimate the translog cost function in (2).

4.2.3. Economies of scale

Economies of scale are calculated as follows:

$$\frac{\partial \ln(TC)}{\partial \ln(Q)} = \frac{\partial TC}{\partial Q}\frac{Q}{TC} = \frac{MC}{AC} \tag{9}$$

In this equation, MC and AC represent respectively the marginal and the average cost, and Q is output. When we apply this to the translog model in (2), we obtain the following scale elasticity coefficients:

[4] Remind that in the random effects model, α_i is the permanent component of the error term, and the prerequisite for consistency is that the exogenous variables x_{it} and the error term are uncorrelated.

$$\varepsilon_{Transet} = \frac{\partial \ln(TC)}{\partial \ln(Transet)}$$
$$= \alpha_1 + \beta_{11} \ln(Transet) + \beta_{12} \ln(VHold) + \lambda_{11} \ln(Lc) + \lambda_{12} \ln(Oc)$$

$$\varepsilon_{VHold} = \frac{\partial \ln(TC)}{\partial \ln(VHold)}$$
$$= \alpha_2 + \beta_{22} \ln(VHold) + \beta_{12} \ln(Transet) + \lambda_{21} \ln(Lc) + \lambda_{22} \ln(Oc) \qquad (10)$$

In equations (10), $\varepsilon_{Transet}$ and ε_{VHold} are the scale elasticity coefficients with respect to the two output variables Transet and VHold. There are scale economies if this elasticity is smaller than one, while there are diseconomies of scale if it is larger than one.

When a multiproduct cost function is assumed, the overall economies of scale are measured as follows:

$$SE = \sum_i \frac{\partial \ln(TC)}{\partial \ln(Q_i)} = \varepsilon_{Transet}(Transet, VHold) + \varepsilon_{VHold}(Transet, VHold) \qquad (11)$$

5. Data

5.1. Data collection

The data set that is used to estimate the cost functions is collected from several publications. The most important source was the annual reports of the CSDs and ICSDs. In addition, the internet sites of the settlement and safekeeping institutions made it possible to enlarge the data set with respect to the output variables. Additional information was also acquired from various issues of the European Central Bank Blue Book on payment and securities settlement systems in the European Union and from the Bank for International Settlement statistics on payment and settlement systems. The data concerning the gross domestic product per capita were obtained from the Datastream database. Finally, some institutions provided us with (data from) annual reports that were not available on their website anymore.

In their paper, Schmiedel et al. also include some North-American and Asian CSDs. However, we prefer to focus only on the European settlement and safekeeping industry, and therefore, only European CSDs are included in our data set. The reason is that in order to guide policy-making in Europe, one can better focus on the empirics of European institutions on their own. In a later stage, European institutions overall then can be compared to their US or Asian counterpart(s).

A number of annual reports were expressed in euro. However, some annual reports are expressed in local currency, like in the United Kingdom, Denmark, Sweden, Norway and Switzerland, while some older annual reports from institutions that are active in countries in the eurozone were still expressed in local currency. The numbers from these annual reports were converted to one single currency, namely the euro (ECU before 1999), on the basis of the exchange rate at the end of each year.

An overview of the settlement and safekeeping institutions that are included in the sample, together with the respective annual reports, is given in table 1. In total, 50 data points are included in our dataset.

Table 1: Sample of Settlement Institutions

Settlement institution	Country	CSD/ICSD	Annual reports
Crestco	United Kingdom	CSD	1997–2002
CSD	Greece	CSD	2002–2003
Interbolsa	Portugal	CSD	2001–2002
Monte Titoli	Italy	CSD	1994–2002
VP	Denmark	CSD	1994–2004
VPC	Sweden	CSD	2003–2004
VPS	Norway	CSD	2000–2004
Sisclear – SegaInterSettle	Switzerland	CSD/ICSD	2001–2004
Clearstream	Germany/Luxemburg	ICSD	2000–2004
Euroclear	France/Belgium/Netherlands	ICSD	2001–2004

5.2. Descriptive statistics

The descriptive statistics for each of the main input and output variables, as well as those for total costs, are represented in table 2. For each variable, the mean is given, as well as the median, the standard deviation, and the minimum and maximum values.

Table 2: Descriptive Statistics

	TC	Lc	Oc	Transet	Vhold
Mean	127553642	43633592	67611066	24648007	$2.1144*10^{12}$
Median	22157561	10737984	9325736	8950000	$3.9431*10^{11}$
Std. Dev.	206338007	71649005	114113951	30159317	$3.1852*10^{12}$
Max	685692000	268697000	477186000	115000000	$1.3100*10^{13}$
Min	7176137	2421560	4148382	906920	$6.5764*10^{10}$
Skewness	1,7747	2,0283	2,0415	1,4704	1,8129

From the table, it is clear that sometimes large differences between the institutions are present. Thus there is quite some heterogeneity present in our sample, as already argued before. A first indication for this is when the minimum and maximum values are compared. These differences can be explained by the fact that the scale of the institutions in our sample is quite diverse. For instance, the ICSDs Euroclear and Clearstream operate on a much larger scale than for instance the Greek or Portuguese CSD, which implies that they have to settle a multitude of transactions compared to the smaller CSDs. Also, the value of the securities that the ICSDs hold in safekeeping is much larger. Consequently, the absolute total costs of the ICSDs are much larger as well.

Moreover, the difference between the mean and the median is sometimes quite significant, again pointing to scale differences. A statistical measure for these differences is the skewness, which captures the asymmetry of the distribution of the series around its mean. If a series has a positive skewness, this means that the distribution has a long right tail, which is clearly the case is our sample. Therefore, it might be more convenient to use the median instead of the mean when the scale elasticities will be calculated. When the median is used, outliers in the sample become less important.

5.3. Average costs

Average cost curves can be used as a first indication of cost efficiency. As explained previously, two output measures are used, namely the number of transactions settled and the value of securities held in safekeeping. The cost in euro per unit of output is given in table 3.

Table 3: Average costs (in euro)

Settlement Institution	TC/Transet	TC/Vhold
Crestco	1,4799	0,0000336
CSD	1,6131	0,0002206
Interbolsa	2,8472	0,0000784
Monte Titoli	3,4508	0,0000232
VP	4,2137	0,0000682
VPC	2,7425	0,0000657
VPS	2,6538	0,0001210
SIS	5,0228	0,0000755
Clearstream	6,3786	0,0000684
Euroclear	9,1579	0,0000630

The first thing that can be noticed is that it costs the CSDs on average between 1.5 and 5 euro to settle a transaction. The average costs to the ICSDs to settle a transaction is however significantly higher, namely somewhere between 5 and 10 euros. This can be explained by the fact that it is much more costly to settle international transactions than domestic ones. The differences in average costs between CSDs and ICSDs can also be seen when we plot the average cost of all data points against the number of transactions settled. This is done in figure 2. On the horizontal axis, the number of transactions settled is given, while the vertical axis represents the average cost in euro per transaction settled.

Figure 2: Average cost (in euro) per transaction settled

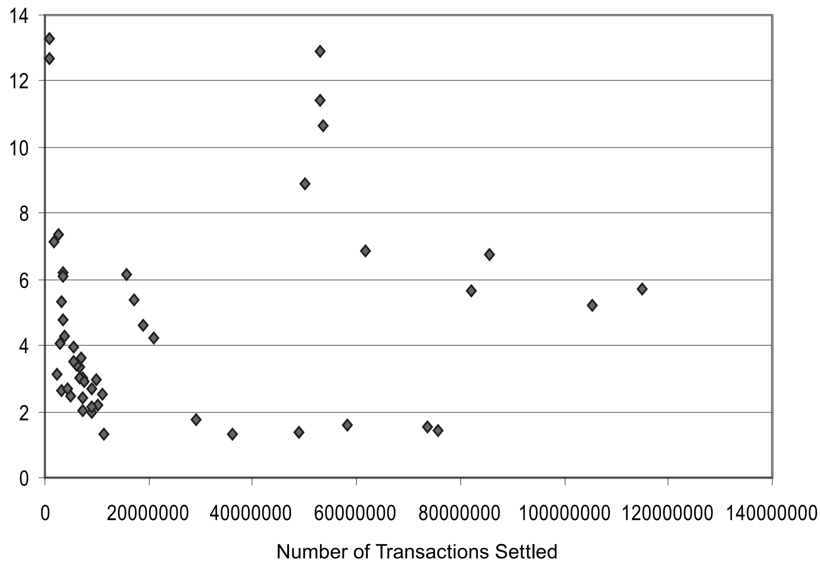
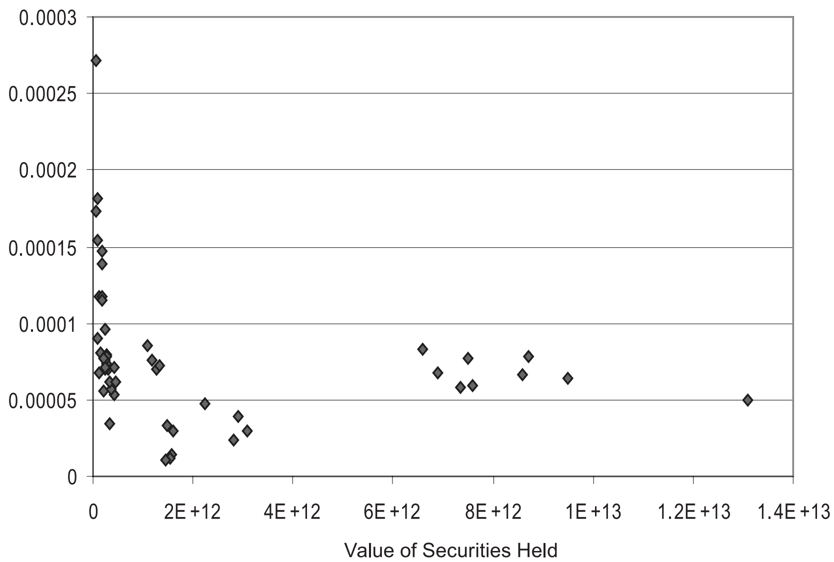


Figure 3: Average cost (in euro) for safekeeping one euro



As can be seen, the average cost goes down quite rapidly. But most remarkable is that there seems to be two average cost curves. The lowest average cost curve is that for the CSDs, while the highest curve reflects the average costs for the ICSDs. This might reflect the fact that the activities of ICSDs are hard to compare with those of CSDs, an argument that was already put forward in Van Cayseele and Wuyts (2005).

Concerning the cost of safekeeping one euro, a distinction between CSDs and ICSDs is harder to make on the basis of table 3, since the institutions seem to be more or less equally cost efficient with respect to this output variable. In figure 3, we plot the average cost against the value of securities held. The data point to the right of a value of securities held of 6000 billion euro represent the average costs of the ICSDs. Again, the CSDs and ICSDs are on a different average cost curve. In addition, the average costs decrease swiftly with regard to this output variable as well.

6. Estimation results

In this section, we estimate the translog cost model that was discussed in section 4. First, we perform some basic regressions. Subsequently, the different estimation techniques that were discussed are applied to the translog cost function.

6.1. Some basic regressions

Before we estimate the full translog cost function, we first estimate some basic regressions whereby we use a loglinear specification to total costs. The output variables that will be used in the remainder of this empirical part are separately and jointly regressed on total costs. In addition, a specification in which the ICSD dummy variable is added is estimated as well. The results can be found in table 4.

Table 4: Total costs regessed on output variables

Model 1a: ln(TC) regressed on 1 output variable (ln(Transet))
Model 1b: ln(TC) regressed on 1 output variable (ln(VHold))
Model 1c: ln(TC) regressed on both output variables
Model 1d: ln(TC) regressed on both output variables and ICSD dummy

Explanatory variables	**Model 1a estimates**	**Model 1b estimates**	**Model 1c estimates**	**Model 1d estimates**
c	2,2154	–4,1141	–2,7483	4,6236
	(1.92)	(–2.95)	(–2.03)	(3.55)
ln(Transet)	0,9460		0,3908	0,4013
	(13.40)		(3.17)	(4.90)
ln(VHold)		0,7971	0,5137	0,2269
		(15.58)	(5.09)	(2.97)
ICSD				1,4969
				(7.79)
R^2	0,7890	0,8348	0,8639	0,9414
Included observations	50	50	50	50

It shows from table 4 that the variables used truly can be seen to be outputs from the settlement and safekeeping process, in that they apparently are “cost drivers” for the system. By this, we mean variables proxying output and correlated with total costs, yet orthogonal to the error term, as explained above. Regarding the ICSD dummy, the cost driver interpretation equally works, although here one can argue that ICSD is a direct characteristic of banking output, putting it on the same level as the variables used in Van Cayseele and Wuyts. For the moment, we leave the discussion as to how ICSD should be interpreted as an avenue for further research.

The regressions in this table are done by means of ordinary least squares (OLS). The t-values are reported in parenthesis. As can be seen, the t-statistics are quite high, and the results are similar to those obtained by Schmiedel et al. From the results, it seems that both variables can be used for further analysis.

Table 5: Estimation of input and output variables

Model 2: ln(TC) regressed on 2 outputs, their interaction term and ICSD dummy
Model 3: ln(TC) regressed on 2 outputs, their interaction term, input price (GDPCap) and ICSD dummy
Model 4a: ln(TC) regressed on 2 outputs, their interaction term; 2 alternative input prices (ln(Lc) and ln(GDPratio)) and ICSD dummy
Model 4b: ln(TC) regressed on 2 outputs and interaction term, 2 alternative input prices and interaction term and ICSD dummy

Explanatory variables	**Model 2 estimates**	**Model 3 estimates**	**Model 4a estimates**	**Model 4b estimates**
c	29,5491 (1.74)	55,1115 (3.78)	35,4611 (2.51)	36,3090 (2.56)
ln(Transet)	–1,1469 (–1.09)	–3,0984 (–3.32)	–1,7856 (–2.03)	–1,4618 (–1.51)
ln(VHold)	–0,6998 (–1.10)	–1,8786 (–3.34)	–1,1979 (–2.24)	–1,0257 (–1.78)
ln(Transet)*ln(VHold)	0,0574 (1.47)	0,1282 (3.72)	0,0815 (2.50)	0,0699 (1.97)
ln(GDPCap)		0,6739 (5.03)		
ln(Lc)			0,6856 (3.92)	0,1704 (0.26)
ln(GDPratio)			–0,3752 (–2.66)	–6,6514 (–0.87)
ln(Lc)*ln(GDPratio)				0,5676 (0.82)
ICSD	1,2466 (4.89)	0,4071 (1.54)	1,0131 (4.46)	1,2207 (3.59)
R^2	0,9441	0,9645	0,9636	0,9641
Included observations	50	50	50	50

However, when the interaction term between the two output variables is included, a problem already comes up. This can be seen in table 5. More in particular, in model 2, the sign of the estimated output coefficients becomes negative, while the interaction term has a positive sign. Moreover, the estimations become insignificant, except for the ICSD dummy. Subsequently, when the input variables are added, this problem continues to exist. These results are similar to those obtained by Schmiedel et al. In model 3, we include as input variable gross domestic product per capita (GDPCap). This is the input variable that was also used by Schmiedel et al. However, as mentioned before, there might be a multicollinearity problem when this variable is used. Therefore, in model 4a, we include the alternative input variables labour price Lc and a proxy for the price of other goods (inputs), that is other costs, because it is hard to find a price for this latter variable. As in Van Cayseele and Wuyts, the price of other costs will be proxied by the ratio of GDP relative to a fixed base year (GDPratio), namely the beginning of 1993. Every end of year value of GDP was then divided by this initial number. In model 4b, the interaction term between the input price variables is added as well. All estimations are done using OLS, and the t-statistics are denoted in parenthesis.

6.2. Estimation of the translog cost function

In this section, the full translog cost function will be estimated. Like in table 5, the model will first be estimated using the input variable of Schmiedel et al. These estimations are done in model 5. In this respect, it is worthwhile recalling that the translog specification put forward in section 4 reads:

$$
\begin{aligned}
\ln(TC) = {} & c + \alpha_1 \ln(Transet) + \alpha_2 \ln(VHold) + \left(\frac{1}{2}\right)\beta_{11} [\ln(Transet)]^2 \\
& + \left(\frac{1}{2}\right)\beta_{22} [\ln(VHold)]^2 + \beta_{12} \ln(Transet)\ln(VHold) \\
& + \gamma_1 \ln(GDPCap) + \left(\frac{1}{2}\right)\delta_{11} [\ln(GDPCap)]^2 \\
& + \lambda_{11} \ln(Transet)\ln(GDPCap) + \lambda_{21} \ln(VHold)\ln(GDPCap) \\
& + \mu_1 ICSD + \varepsilon \qquad (12)
\end{aligned}
$$

Subsequently, in model 6, the translog cost function that was described in equation (2) will be estimated, whereby the alternative input variables Lc and GDPratio are applied. More specifically, equation (13) below will be estimated:

$$\begin{aligned} \ln(TC) = {} & c + \alpha_1 \ln(Transet) + \alpha_2 \ln(VHold) + \left(\frac{1}{2}\right)\beta_{11}\left[\ln(Transet)\right]^2 \\ & + \left(\frac{1}{2}\right)\beta_{22}\left[\ln(VHold)\right]^2 + \beta_{12}\ln(Transet)\ln(VHold) \\ & + \gamma_1 \ln(Lc) + \gamma_2 \ln(GDPRatio) + \left(\frac{1}{2}\right)\delta_{11}\left[\ln(Lc)\right]^2 \\ & + \left(\frac{1}{2}\right)\delta_{22}\left[\ln(GDPRatio)\right]^2 + \delta_{12}\ln(Lc)\ln(GDPRatio) \\ & + \lambda_{11}\ln(Transet)\ln(Lc) + \lambda_{12}\ln(Transet)\ln(GDPRatio) \\ & + \lambda_{21}\ln(VHold)\ln(Lc) + \lambda_{22}\ln(VHold)\ln(GDPRatio) \\ & + \mu_1 ICSD + \varepsilon \end{aligned} \tag{13}$$

Several estimation techniques are used to estimate the models. First, in the RE models, the random effects GLS regression is used, while subsequently, the fixed effects regression is executed in the FE models. In model 6, the estimation results of the translog cost function whereby the Seemingly Unrelated Regression (SUR) technique is used are given as well. Here, the share equations (3) are added to the system. The results for model 5 can be found in table 6, while the results for model 6 are represented in table 7. As usual, the t-statistics are denoted in parenthesis. Also, three coefficients of determination are reported, namely the within, the between and the overall coefficient.

Model 5 RE in table 6 reproduces the results of Schmiedel et al. Like in their estimation results, the output variables Transet and VHold have a negative sign, which would imply that total operating costs would decrease as output increases. Also, one of the squared output terms, namely $(\ln(\text{VHold}))^2$, has a negative sign, while in Schmiedel et al., both squared output terms are negative. Concerning the output interaction term, we obtain a negative sign, as it should be, as opposed to Schmiedel et al. Finally, the input price variable lnGDPcap has a negative coefficient. However, aside from the negative output coefficients, another defect is that neither in our estimation results of model 5a, nor in the results of Schmiedel et al., almost any

Table 6: Estimation of the translog cost function using GDP per Capita

Model 5 RE: Estimation of translog cost function (12) using random effects
Model 5 FE: Estimation of translog cost function (12) using fixed effects

Explanatory variables	Model 5 RE estimates	Model 5 FE estimates
c	120,5008 (4.18)	53,8605 (1.53)
ln(Transet)	–0,4304 (–0.35)	3,6100 (1.70)
ln(VHold)	–4,7632 (–1.55)	–6,1191 (–2.12)
$(\ln(Transet))^2$	0,3463 (1.71)	0,6566 (3.54)
$(\ln(VHold))^2$	–0,0525 (–0.44)	0,4848 (2.60)
ln(Transet)*ln(VHold)	–0,0509 (–0.43)	–0,3648 (2.22)
ln(GDPcap)	–9,2933 (–1.18)	2,4892 (0.32)
$(\ln(GDPcap))^2$	–0,3297 (–0.35)	0,7626 (0.64)
ln(Transet)*ln(GDPcap)	–0,3403 (–1.79)	–0,3968 (–1.11)
ln(VHold)*ln(GDPcap)	0,7131 (5.65)	–0,1189 (0.48)
ICSD	–0,8915 (–2.09)	(dropped)
R^2 within	0,5926	0,7388
R^2 between	0,9958	0,6878
R^2 overall	0,9814	0,7434
Included observations	50	50

estimated coefficient is statistically different from zero at a reasonable significance level.

When we apply the fixed effects regression, the results change however in a remarkable way as can be seen in model 5 FE. One of the output variables, ln(Transet), alters to a positive sign and is significant at the 10% level, both squared output variables $(\ln(Transet))^2$ and $(\ln(VHold))^2$ are positive as well and significant at respectively the 1% level, and the 5% level, and the output interaction term ln(Transet)*ln(VHold) becomes negative and is significant at the 5% level. The latter is an indication that the joint production of settlement and safekeeping leads to efficiency gains. The input price variable now has a positive sign as well, although it remains insignificant. Finally, in the fixed effects regression, the ICSD dummy is dropped, given its incompatibility with the fixed effects regression strategy.

Clearly, the fixed effects regression leads to much more sensible results than the random effects regression. However, this does not provide evidence that the fixed effects model should be preferred, although some intuitive reasons were already mentioned in section 4.2.2. A more formal test can be used, viz. the Hausman test. When this test statistic is computed, a value of 97.03 is obtained. Under the null hypothesis that the differences in the estimated coefficients are not systematic, this statistic follows a chi-squared distribution. Clearly the null hypothesis has to be rejected, indicating that there might be correlation between the permanent component of the error term and the exogenous variables. Therefore, the fixed effects model is the preferred one.

Table 7 reports the estimation results of the translog cost function of equation (2). The alternative input prices are used instead of GDPcap because of the reasons mentioned in section 4.1. First, in model 6 SUR, the SUR technique is used, in which the translog cost function is estimated jointly with the share equations. No conclusion can be reached since the estimated coefficients are very insignificant. When we use the RE technique, as in model 6 RE, we see that the estimation results improve strikingly, not only compared to the SUR estimation, but also compared to the estimation results of model 5 RE reported in table 6. This might be an indication that multicollinearity may be present between the gross domestic product per capita and the value of securities held in safekeeping. More in particular, the output variable ln(Transet) is positive and almost significant at the 5% level, while the squared output terms are positive and the output interaction term is negative, although these are not significant. Also, one input price variable ln(Lc) is positive as well. Thus, by including the alternative input prices ln(Lc) and ln(GDPratio), it is possible to improve the results considerably.

When we now execute the fixed effects regression to the full translog cost model, we obtain the results of model 6 FE. The sign of the estimated coefficients stays unchanged compared to the random effects regression of model 6 RE, but the t-statistics improve. More specifically, ln(Transet) is now significant at the 5% level, while $(\ln(Transet))^2$, $(\ln(VHold))^2$ and

Table 7: Estimation of the translog cost function using L_c and GDPratio

Model 6 SUR: Estimation of translog cost function (13) and share equations using seemingly unrelated regression technique
Model 6 RE: Estimation of translog cost function (13) using random effects
Model 6 FE: Estimation of translog cost function (13) using fixed effects

Explanatory variables	Model 6 SUR estimates	Model 6 RE estimates	Model 6 FE estimates
c	11,4005 (0.37)	144,3623 (2.87)	57,0669 (0.78)
ln(Transet)	–1,8770 (–1.30)	11,9003 (1.94)	11,2245 (2.08)
ln(VHold)	0,5032 (0.20)	–20,6030 (–3.08)	–13,1923 (–2.24)
$(\ln(Transet))^2$	0,0000 (–1.06)	0,4098 (1.29)	0,7589 (2.90)
$(\ln(VHold))^2$	–0,0714 (–0.65)	0,3373 (1.46)	0,5901 (2.72)
ln(Transet)*ln(VHold)	0,1115 (2.05)	–0,3742 (–1.44)	–0,5607 (–2.84)
ln(Lc)	1,0433 (2.40)	10,2072 (0.92)	9,1142 (0.96)
ln(GDPratio)	–0,2838 (–0.63)	–36,4804 (–1.44)	–16,6637 (–1.08)
$\ln(Lc)^2$	0,0943 (2.01)	–3,8831 (–2.24)	–1,1486 (–1.05)
$\ln(GDPratio)^2$	0,0433 (0.72)	0,9648 (0.80)	4,8239 (2.61)
ln(Lc)*ln(GDPratio)	–0,0695 (–1.85)	3,6240 (2.00)	1,1179 (1.03)
ln(Transet)*ln(Lc)	–0,0687 (–3.08)	–0,7003 (–1.75)	–0,6997 (–1.58)
ln(Transet)*ln(GDPratio)	0,0161 (0.48)	–0,3853 (–0.61)	–0,3330 (–1.02)
ln(VHold)*ln(Lc)	–0,0188 (–0.92)	1,5891 (3.69)	0,5392 (1.08)
ln(VHold)*ln(GDPratio)	0,0453 (1.48)	0,0208 (0.03)	0,2235 (0.48)
ICSD	1,7960 (5.52)	0,2225 (0.23)	(dropped)
R^2 within	0,9371	0,4956	0,8132
R^2 between		0,9939	0,0305
R^2 overall		0,9822	0,0398
R^2 share Lc	0,5223		
R^2 share Oc	0,2343		
Included observations	50	50	50

ln(Transet)*ln(VHold) have the appropriate sign and are significant at the 1% level. The results for the input prices are similar to those of the random effects regression. Like in model 5 FE, the ICSD dummy is dropped.

This time, it is less clear that the random effects or the fixed effects model is preferred, since the estimation results are similar. But a formal analysis shows that a Hausman test statistic of 31.53 is obtained. Thus, the null hypothesis has to be rejected once more and the fixed effects model is the preferred model.

6.3. Economies of scale

The economies of scale are calculated for each output factor, and the overall scale economies are calculated as well. This is done through the estimation of the scale elasticities in equation (10) at the sample mean as well as at the median. However, from table 2, it is clear that the sample is biased towards the larger institutions (mainly the ICSDs). Therefore, only the results whereby the mean is used are reported. Sometimes it might be useful to consider the economies of scale along an expansion path. This can be done by regressing the two output variables on each other. This was also done by Schmiedel et al. The estimation results for this loglinear expansion path, namely ln(VHold)=f(ln(Transet)), is reported in appendix A. As a result, the median values of VHold are forecasted by this expansion path. The scale elasticities indicate how total costs react if the output variables Transet and VHold are increased. More in particular, they show how the cost per unit resulting from an increased production of the service is reduced. Thus, when economies of scale are present, average costs decrease as output increases.

To calculate the scale elasticities, the sample is divided into four quartiles. This division occurred on the basis of the number of transactions settled. Q1 denotes the smallest institutions whereby Q4 are the largest ones. First, we reproduce the scale elasticities introduced in Schmiedel et al. To do this, the estimation results from model 5 RE in table 6 are used. The results can be found in table 8. Next, we compute the scale elasticities according to the estimation results from model 6 FE in table 7. As argued, this is the preferred model. The results are given in table 9. In both tables, the t-statistics are denoted in parenthesis to indicate whether an elasticity is significantly different from one. The t-statistics are calculated by evaluating the elasticities on each observation, then taking the standard error of these elasticities for each group of institutions.

Table 8: Economies of scale using model 5 RE

The scale elasticities are calculated by taking the first derivative of the translog cost function with respect to each output variable

There are scale economies if this elasticity is smaller than 1

	$\varepsilon_{Transet}$	ε_{VHold}	SE
Q1	0,0395	0,2383	0,2778
	(7.42)	(3.30)	(3.69)
Q2	0,1521	0,3988	0,5509
	(9.33)	(2.87)	(3.29)
Q3	0,3775	0,3504	0,7279
	(2.75)	(2.08)	(1.52)
Q4	0,5062	0,8118	1,3180
	(2.67)	(0.54)	(1.67)

Table 9: Economies of scale using model 6 FE

The scale elasticities are calculated by taking the first derivative of the translog cost function with respect to each output variable

There are scale economies if this elasticity is smaller than 1

	$\varepsilon_{Transet}$	ε_{VHold}	SE
Q1	0,2423	0,0926	0,3349
	(7.10)	(5.79)	(8.25)
Q2	0,2209	0,2901	0,5111
	(4.38)	(4.67)	(10.86)
Q3	0,2616	0,3224	0,5839
	(2.72)	(3.04)	(3.11)
Q4	0,3828	0,4362	0,8190
	(8.99)	(8.61)	(2.92)

From table 8, it would seem that with respect to the number of transactions settled, the smallest institutions are able to achieve enormous scale economies, while even the largest institutions have a large potential for costs savings. Also, with respect to the value of securities held, the CSDs in the lowest quartile have a low scale elasticity, while the CSDs in the highest quartile have an elasticity that is much closer to one. This quartile consists mainly of observation of the two ICSDs, together with some observations of the British CSD. When we look at the overall scale economies, which is the last column in the table, economies of scale seem to exist for the CSDs in the three lowest subsamples, while the largest subsample would incur diseconomies of scale. However, no judgements should be made on the basis of this table, since first of all, the t-statistics are quite low, and the overall scale elasticity is not significant at the 5% level for this group. Moreover, as discussed before, the estimations of this model may not be correct.

This becomes clear when we look at the results in table 9. The extent to which there are economies of scale varies between institutions, but also between the output variable that is considered. The three smallest subsamples have a more or less equal potential for cost savings with respect to the number of transactions settled, while the ICSDs can still exploit substantial cost savings as well, although to a lesser extent than the other CSDs. Concerning the value of securities held in safekeeping, the smallest CSDs have larger scale economies for this output variable, while the opposite holds for the three other quartiles. In addition, the overall scale elasticities are higher for the ICSDs, but even these institutions still can obtain considerable cost savings. This result clearly contradicts that of table 8, where the ICSDs seemed to suffer from diseconomies of scale. Finally, the t-statistics indicate that all scale elasticities, and even the sum of both, are significantly different from 1. Therefore, further horizontal consolidation could be rationalised from efficiency gains, at least when outputs are proxied by the variables used in this study.

7. Conclusion

The European settlement and safekeeping industry is currently examined thoroughly by policy makers. The European Commission is investigating how competition in this industry can be further encouraged and how post-trading costs can be lowered in particular in order to reduce cross-border overall trading to post-trading costs and create a true single European financial market. While domestic settlement in Europe is rather cheap and aligned to international standards, the settlement of cross-border trades is still quite expensive. However, concerns regarding the revenues of the institutions must be combined with concerns for the costs incurred by all the institutions and investors that are involved in securities transactions.

The current settlement arrangements are efficient at the national level, but they appear to be inefficient for cross-border trades. This is due to the fact that in the past cross-border trading has been very limited, and as a result, most attention was paid to the domestic infrastructure. Compared to domestic settlement, the inefficiencies regarding the cross-border trades stem from the absence of common technical standards, the existence of different business practices and an inconsistent fiscal, legal and regulatory framework. This increases costs and makes cross-border settlement also more complex than the settlement of domestic trades.

Also the safety aspects for all involved parties deserve attention in this respect. The reason is that the clearing and settlement systems are of critical importance for a well functioning capital market, but also for financial stability. They are important for capital markets because these systems finalise securities transactions, and this needs to take place in an efficient and secure environment in order to minimise the possibility that one of the parties cannot fulfil its obligations.

In addition, market liquidity depends on the faith regarding the safety and reliability of the settlement arrangements. Markets participants may not be willing to trade anymore if they believe that there is a substantial possibility that a trade will never settle. Moreover, weaknesses in securities settlement systems can give rise to systemic disturbances in securities markets, and in this way there might be some spillover effects to other payment and settlement systems, affecting overall financial stability. If any of the institutions that execute fundamental functions in the settlement process or even if a major user of the settlement system is faced with some financial or operational problems, this will lead to serious liquidity pressures or credit losses for the other participants. Thus, it is necessary that settlement systems are stable and secure.

According to the report of the European Commission (2004), the securities settlement systems are characterised by large economies of scale and scope. Concerning the economies of scale, this result is confirmed in the empirical analysis of this paper. In order to verify the existence of pronounced scale economies, a cost function has to be estimated. Methodologically, although the institutions that are active in the European settlement and safekeeping industry area are quite different in terms of the underlying technology and the nature of the outputs provided, a sensible cost function only can be estimated provided that one properly takes into account this heterogeneity. More in particular, by applying the fixed effects regression instead of OLS or a random effects regression, we find that the signs of the estimated coefficient become much more in line with the received microeconomics of production theory. Also, contrary to the OLS estimation results, the estimated coefficients in the fixed effects regression are significant at least at the 5% level.

With respect to the scale economies, we find that performing the fixed effects regression or a random effects regression results in different conclusions. The random effects regression suggests that the largest institutions would incur diseconomies of scale since their overall scale elasticity coefficient is larger than 1, although it is not significant. When we calculate the scale elasticity coefficients by means of the estimated coefficients of the fixed effects regression, which takes into account the heterogeneity between the institutions, we can conclude that all institutions, even the largest ones, can profit from scale economies. Moreover, the calculated elasticities are significantly different from 1, indicting that substantial cost savings can be obtained. Therefore, one can conclude that further consolidation still could result in cost savings in Europe, since scale economies will be exploited further. This is also in line with the recommendation of CPSS and IOSCO concerning efficiency that was mentioned in the introduction.

A stable and efficient clearing and settlement system needs to exploit all possible efficiency gains. This concerns not only technical efficiency, which implies that output is produced in an efficient way, but also allocative efficiency, which states that the institutions should charge competitive prices. As argued in Van Cayseele (2004) and Serifsoy and Weiss (2005), it is not obvious to combine these two objectives in an industry where large scale economies are present. The configuration where there is a fragmented infrastructure which charges competitive prices but foregoes important scale and scope economies needs to be balanced against a configuration where there is a concentrated infrastructure that optimally exploits these economies but with the risk of acting more independently from consumers interests (governances practices that are not discussed here could at least partially overcome this concern). In fact, this is where the main difference between domestic and cross-border trading is located. On the domestic level, there are a limited number of providers, often there is only one CSD in every country with some few specialised banks offering settlement and custody services. On the cross-border level however, the fragmentation of the infrastructure is a source of additional costs (lack of harmonisation and interoperability) and the size of the individual providers would not allow to optimally take advantage of the economies of scale and scope in the clearing and settlement industry. Therefore, further horizontal consolidation can give rise to a better exploitation of efficiency gains, as shows from the empirical part of this contribution. The European Commission also aims at the liberalisation and integration of the clearing and settlement industry in Europe combined with a continued application of competition policy. Essentially, this is a combination of applying technical and allocative efficiency, and hence is confirmed by the results of the present study, which introduced the appropriate econometric tools for investigating panel data in the debate.

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9. Appendix A

In this appendix, we regress one output variable on the other. The estimated coefficients are used to forecast the values of ln(VHold) when calculating economies of scale in section 6.3 according to equation (10).

Table A1: Estimation of linear logarithmic expansion path

Dependent Variable: ln(VHold)	
Explanatory variables	**Coefficient Estimates**
c	9,6630
	(7.23)
ln(Transet)	1,0808
	(13.20)
R–squared	0,7839
Included observations	50

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