

# Cost Efficiency in the European Securities Settlement and Safekeeping Industry<sup>1</sup>

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## **Abstract**

We examine whether the European settlement and custody institutions operate in an efficient way. To do this, we start from an analytically founded discussion regarding the activities performed by the operators in this sector. Based on the insights obtained, we estimate both a translog cost function and a constant elasticity of substitution - quadratic cost function. From the results obtained, there clearly are economies of scale in this industry. Moreover, also economies of scope between the activities performed are present. These findings imply that probably further consolidation is ahead, and that separating certain activities from others can only be done at a cost in terms of efficiency.

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# 1 Introduction

During the last decades, trading on securities markets increased considerably. Moreover, the international trade of securities strongly increased. This implies that not only more transactions need to be settled, but that instead more of these transactions need international settlement.

In order to settle a securities transaction, entries have to be made in the books of the organisations that keep track of the ownership of the security. In general, once securities have been emitted by a firm, they remain in the Central Securities Depository (CSD). The CSD keeps track of the ownership of the securities. This implies that investors either directly hold a securities account in the CSD, or indirectly through a financial institution (local agent bank) who then in turn has an account in the CSD.

A brief overview of the structure of the settlement industry in Europe shows that compared to other markets, like the USA, the European infrastructure still is quite fragmented. This is caused by the fact that in Europe the majority of the securities were traded on a national level, partly as the result of the existence of different currencies. As a result, several (national) CSDs continue to coexist, and only recently some consolidation has taken place.

The question therefore is whether market structure should remain as it is, or whether consolidation should continue. On the one hand, there is a presumption that there is an efficient infrastructure for domestic trades in each country, although further scale economies possibly could be exploited. On the other hand, however, there is an inefficient infrastructure for cross-border trades, since a wide range of procedures, regulations and systems exist in the different countries. This can give rise to additional costs and risks. According to some opinions, like Cruickshank (2001), the greatest source of inefficiency in capital markets can be found in the clearing and settlement industry.

In addition, CSDs also provide services to the companies that have emitted and deposited securities. When a company for example needs to communicate with its shareholders in the event of a general assembly, it often will rely on the services of the CSD who kept track of the ownership of the stock. Hence comes up the issue whether or not the services provided to the companies should be done by the same entity who provides the settlement services to the investors. While the latter activity is done in

competition with local agent banks and to a certain extent with global custodians, the first is mostly done on an exclusive basis with the company that issued the securities and deposited them in a particular CSD.

Until now, little attention has been given to these issues. To our knowledge, only Schmiedel, Malkamäki and Tarkka (2002) have examined the efficiency of the clearing and settlement industry. However, as will be discussed below, they use a quite general measure for the input variable in the cost function, and they obtain quite particular estimates for the cost function estimated. Therefore, we will use more specific measures for input variables and we will explicitly take into account the multiproduct nature of the players in this industry by focussing on an appropriate proxy for services provided to both emittents and investors.

By estimating cost functions, we aim at shedding further light on the existence of scale and scope economies in the European settlement and safekeeping industry. A good understanding of these issues is essential to know what the equilibrium market structure will tend to be. Therefore, the rest of this contribution is organised as follows. The next section provides a description of the industry and identifies a number of policy issues. In the third section, the model that will be estimated is discussed in detail. A few unresolved questions and puzzles relating to previous work on this industry, as well as the appropriateness of particular specifications for a cost function are discussed. A fourth section describes the data used in the present study while the fifth section contains the results obtained. The sixth section concludes with a few policy recommendations.

## **2 The European settlement and safekeeping industry: Some facts and analytical insights**

Clearing and settlement services are important for a properly functioning securities market. Since the trading of securities involve a transfer of a security as well as a payment in the opposite direction, this has to take place in a way that is efficient and secure. The same holds true for the payment of a coupon by the emittent of a bond to its investors. The clearing, settlement and safekeeping institutions assure that these transactions are completed safely. But as mentioned already, not everyone is convinced that, especially with respect to cross-border settlement, this is done in the most efficient way.

The European clearing, settlement and safekeeping industry essentially hosts three types of institutions, see also Milne (2002) for a discussion of the activities that are taken care of by these players. We discuss them briefly, starting from the point where a trade has realised, for example on a stock exchange. After that the trade has been accomplished, the first thing that needs to be done is the clearing. We only describe briefly here what clearing involves, as this activity is the least important from the perspective of this paper.

In the clearing stage, the obligations of the buyer and the seller are determined. The transactions in financial markets can be cleared by a number of institutions, for instance 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.

The 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. In a securities market, it is also possible to trade with a central counterparty (CCP). This institution poses itself between the buyer and the seller, so that both parties remain anonymous to each other since they deal directly with the CCP. In addition, a CCP can also offer a netting facility. Here, all gross positions are offset against each other so that all outstanding positions are converted to a single debit or credit between the CCP and another party. It is well-known that such a multilateral netting facility strongly economizes on the total number of transactions, see Greenbaum and Thakor (1995). Hence, often a single player will be active in a particular market due to the existence of pronounced network effects.

After that the clearing process is finished, the settlement of the transaction has to be executed. This implies the transfer of money from the buyer to the seller, while the delivery of the securities goes in the opposite direction. Most of the time, the transfer takes place via book-entries instead of by physical delivery since in the European Union the majority of the securities is immobilised or dematerialised. The delivery is typically executed in a CSD or an ICSD. A CSD or Central Securities Depository is an institution that provides the settlement for domestic trades. An ICSD or International Central Securities Depository settles trades in international and internationally traded domestic securities. At the moment there are two European ICSDs, namely Clearstream and Euroclear. These institutions find their origin in the

expansion of the Eurobond market in the 1960s, and their purpose was to develop settlement services for this market. Nowadays, the activities of these institutions are expanded so that a large type of bonds and other securities like equities can be covered, also for domestic settlement purposes. More specifically, Euroclear Bank settles the transactions on Euronext, thus acting as the CSD for Belgium, France and the Netherlands, while Clearstream acts as the CSD for Germany and Luxembourg.

One way of settling is the so-called “Delivery versus Payment” (DVP) procedure. According to this settlement procedure, the transfer of securities from the buyer to the seller only takes place if the payment from the seller is received. In addition to the settlement of trades by “outside” parties, trades can be settled internally by local agent banks. These are the banks that act on behalf of the investors who engage in trading. When a trade takes place between investors who happen to use the same local agent bank, the latter can settle “on his own books”, without needing a CSD or an ICSD. Hence, although in a single country or even a group of countries one often only finds one (I)CSD, several players are active in the process of settling securities trades, see Van Cayseele (2004).

This brings us to the third and final type of institutions that are present in the European clearing, settlement and safekeeping industry. Paradoxically, one could claim that these institutions neither constitute a novel type, nor that they belong to the clearing and settlement industry. So on the one hand, the third type of institution provides a different service, namely safekeeping or “custody”<sup>1</sup>. Yet the players involved in safekeeping or custody are exactly those mentioned when we discussed settlement. The solution to the paradox is to be found in the multiproduct nature of the business involved.

Settlement occurs as the result of a trade, which is a change in the position an investor holds. For example, when X sells his stock of company A to investor Y, Y now holds a claim on company A, instead of X. So the positions of X and Y have changed. But track of the positions of X and Y regarding their holdings of stock of company A also has to be kept, *regardless* whether a trade has occurred. Both X and Y might hold stock of company B, on which they do not wish to trade. This service is called custody and concerns the safekeeping of the securities as well as their administration on behalf of companies and investors.

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<sup>1</sup>We will not distinguish between the terms safekeeping and custody, although sometimes safekeeping is used for the emittent side and custody for the investor side of the market.

Safekeeping entails more than merely keeping a record of the existing positions, since assets sometimes need to be serviced. When the general assembly of a company that has emitted stock in a particular CSD decides to pay a dividend, all the owners of shares need to receive it. Or when the company decides to emit additional shares against a number of coupons and money, all the previous owners who decide that they want additional shares should receive them against their coupons, a.s.o.

In principle, one could completely separate the safekeeping and asset servicing activity on the one hand from the settlement services on the other hand. In order to see how this could work, consider the following entirely hypothetical market structure. On the one hand, all the securities that are emitted in a country are deposited in a single CSD. On the other hand, all the investors have their securities account with a single monopoly local agent bank<sup>2</sup>. It then becomes possible for this local agent bank to settle all the transactions in any particular security, since every trade merely requires the debiting and crediting of securities and cash accounts that all are held with the local agent bank. When the companies decide on their dividend policy, the CSD becomes active and transmits to the single monopoly local agent bank all the necessary funds against the required coupons.

As another extreme, it is equally conceivable to fully integrate the safekeeping and asset servicing activities with the settlement function. All the trades can be settled on the accounts of the investors with the CSD, and dividend policy can be implemented directly instead of through a transfer to a local agent bank. This direct holding of investor accounts by the CSD constitutes the so-called Scandinavian model.

Finally, also intermediate outcomes are conceivable, in which some investors have a securities account with the CSD, while others are with the local agent bank<sup>3</sup>. Holthausen and Tapking (2004) investigate such an intermediate solution when the investors are replaced by local agent banks (who in turn represent investors) and the single monopoly local agent bank is a large global custodian. They ask whether the CSD can distort the competition with the large global custodian by raising the price

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<sup>2</sup>This could be the result of a pronounced merger wave in the banking industry, or a number of local agent banks might have an agreement to cooperate regarding the settlement of transactions. As an interesting side product of using our data set, we have regressed the volume of transactions settled on the books of the CSDs on the concentration ratio of the retail bank sector in the corresponding year and country that the CSD operated. Appendix A documents a statistically significant and negative relationship to exist between the two variables.

<sup>3</sup>All securities emitted however are deposited in a single CSD. Otherwise, investors would need multiple accounts, and depending on the particular share they own, their ownership would be established by a certain CSD.

charged to this player<sup>4</sup>. They conclude that this strategy of “raising a rival’s costs” might not be detrimental to social welfare. The reason is that it reduces the market share of the large custodian and the resulting positive network externalities created by the fact that the CSD can settle more transactions, outweigh some disadvantages in terms of horizontal product differentiation.

The positive network externalities mentioned are typically those generated within a two-sided network, see Economides and White (1994). Two-sided networks have the characteristic that any new participant in the network creates  $2n$  new goods, where  $n$  is the number of participants before the new one joined. In order to illustrate this somewhat further, consider a telephone network in which already five clients denoted by A, B, ..., E participate. Each ordered couple then constitutes a product, i.e. (A, B) means that A calls B, while (D, A) indicates that D calls A. When G joins the network, this implies that now the products (A, G), (B, G), a.s.o. can be made, but also G can make calls and create (G, A), (G, B), ..., which constitutes another five new products, so that overall the product space is enlarged with 10 ( $= 2n$ ) new items. For  $N$  clients, the total size of the product space is  $N(N - 1)$ .

Any couple of capital letters in the example above could instead of a telephone call constitute a sale of a share. (A, B) then denotes the selling of stock from A to B, while (B, A) denotes that B sells to A. Clearly then the intermediary that settles these trades, regardless whether it is the CSD, the single monopoly local agent bank or the global custodian, will realize larger network externalities the more investors participate in that network. Competing networks will destroy these positive externalities in that they will need “bridges” to provide for access to the rival network. This will be necessary to realize all conceivable products.

The conclusion then is simple and straightforward: in the two-sided network that constitutes settlement activities, either the fully integrated or the completely separated solution makes sense. With the first solution, the CSD realizes the full potential of the network externalities, while with the second solution, this is done by the single monopoly local agent bank.

The latter however in reality does not exist, and hence one might from this perspective argue that a “Scandinavian outcome” where all investors directly participate in the CSD then is preferable. In our view, this however is not an appropriate answer

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<sup>4</sup>In order to settle particular trades, the large custodian needs the CSD who is the ultimate bookkeeper of the security.

to whether one should favour a fully integrated or a fully separated solution. Indeed, one could, even without merging all local agent banks into one, create a network that internalizes all of the settlement activities. One could even include the CSD in this network, linking up all local agent banks and the CSD. As long as the costs of building and operating the “bridges” that provide access to each other’s accounts are not too expensive, such a “multiple link” constellation will probably not fall far below the efficiency reached by the fully integrated or the single monopoly local agent bank solution, but it remains an empirical matter to determine the exact magnitude of the efficiency loss.

Analytically, a different approach can be taken to argue in favour of one outcome or the other. The asset servicing activities performed by the CSD constitute a so-called one-sided network. An example of a one-sided network is electricity. On one side of the network, there are the households (and firms) consuming electricity. On the other side of the “grid” are the power plants who generate the electricity. Here, when large caps denote households and numbers denote power plants, the couple (1, A) constitutes a product, indicating that plant 1 delivers electricity to household A, but (1, 2) or (A, B), nor (A, 1) for the matter constitute a (new) product. The size of the product space when there are  $M$  power plants and  $N$  households is  $M \times N$ .

Asset servicing, corporate action, ... fit a one-sided network constellation. When  $M$  companies have deposited the emission of one asset each (comprising many individual securities) in the CSD, and when all  $N$  investors hold a completely diversified portfolio, and finally when dividend policy decisions are taken annually, each year the CSD will need to perform  $M \times N$  operations to pay out the dividends. Since the CSD holds all the securities in an emission, the issue is not whether a single CSD should do all the asset servicing of this security or not, but whether or not the CSD should combine settlement activities with asset servicing, i.e. whether the fully integrated solution should be withheld<sup>5</sup>. Technically, one then combines a two-sided network (settlement) with a one-sided (asset servicing) within a single operator, the CSD. The question is: does this increase industry performance?<sup>6</sup>

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<sup>5</sup>There could be several fully integrated CSDs coexisting. And indeed, in some countries there is sometimes more than one player in the market. On the European scene, all the national and international CSDs coexist, so there is a choice for companies to emit securities where they see it most fit. That of course will also depend on for example the listing and hence liquidity of a related stock exchange. We however will indicate why there are advantages of all companies emitting, depositing in just a few CSDs, when discussing the results regarding scale economies.

<sup>6</sup>It is worth noting that few other examples of industries exist that combine a one way with a two way network. However, a number of examples exist where an attempt is made to engage in such a business model. More in particular, cable distributors (who ensure that television stations can be

A priori, there could be several reasons why the answer to this question is to be answered affirmatively. One reason is that keeping the account of an investor for asset servicing purposes without any additional cost also can be used for settlement purposes. This argument is entirely motivated by efficiency reasons. It avoids duplicating accounts. Maybe, this only might induce minor cost savings. But it also could avoid errors (a booking from the CSD to the single monopoly local agent bank, and then to all the investors' accounts involves one step more than a direct solution), that tend to be more expensive for their resolution typically entails judgement and negotiation and hence time and manpower.

In addition to these technical efficiency reasons, the network externalities should be kept in mind. The size of the product space increases both in  $M$  (number of securities) and  $N$  (number of clients), and this for *both* activities. This has important implications. Suppose a stand alone local agent bank succeeds in attracting an additional investor. This makes the player more attractive to other investors, who know that their potential trades with others can be settled internally. But to companies who emit securities, the fact that an investor has joined a particular local agent bank does not make a particular CSD a more attractive player. Similarly, suppose a stand alone CSD succeeds in attracting an additional company to float their stock and deposit it. This does not make a particular local agent bank more attractive.

But suppose that a CSD who is active both in asset servicing and settlement of trades attracts an additional investor. This makes this particular player more attractive both to investors and companies. A company knows that it can transfer most of the dividend payments to this particular CSD, since most investors have a securities account in the CSD. An investor knows that trades with this additional new investor can be settled through this particular CSD too. Hence, the *efforts* necessary to attract an additional investor yield benefits on both the investor and emittent side of the market for a fully integrated CSD. Stand alone players therefore might need more investment in advertising or other recruiting expenditures to attract additional customers than the fully integrated CSD. This in turn might imply that the fully integrated CSD can invest the means it does not need to invest in advertising

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received at home) - a typical one way network - try to combine this service nowadays more and more with telecommunication services - a typical two way network. Conversely, telephone companies try to expand their telecommunication services into the distribution of television content. These initiatives all are very recent, and it seems that little if anything can be learnt from these experiences. On the contrary, the settlement and safekeeping industry has a far longer track record of employing this business model of combining a one with a two way network in a freely competitive, unregulated environment.

expenditures into cost efficient technologies such as better IT equipment and support<sup>7</sup>.

This will lead to lower operating costs for settlement and asset servicing when both activities are combined in a fully integrated CSD. Since such a player caters for two different sides of the market, we will refer to it from now on as being a “platform”<sup>8</sup>. It remains to be investigated whether the improved conditions for attracting larger numbers of investors will induce a reduction in advertising expenditures in favour of better technological solutions. But the conjecture is certainly plausible, and together with the efficiencies realised, it could induce economies of scope between asset servicing and safekeeping on the one hand, and settlement on the other.

Whether efficiencies and network externalities can be better exploited by fully integrated CSDs then in the end needs to be verified empirically, for it will depend among other things on the trade patterns, the diversification of the portfolios held by the investors, the inclination to invest in superior IT technology, a.s.o. The rest of the present contribution aims at clarifying some of these issues by estimating, among other specifications, a multiproduct translog cost function.

The next section therefore investigates empirically whether the matching of a one-sided network with a two-sided network makes sense economically. It exploits the opportunity to discuss previous findings in the literature and explain the research strategy employed to shed light on some puzzling findings.

## 3 The model

### 3.1 Variables

As been said in the introduction, the only paper that analyzes economies of scale and scope in the securities settlement industry is the Bank of Finland discussion paper of Schmiedel, Malkamäki and Tarkka. This paper produces some remarkable findings. Notably it is the case that costs seem to decrease as one output, namely custodian

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<sup>7</sup>Often, CSDs as well as ICSDs are user-owned and governed, and hence the stakeholders might push the platform into improved IT investment, since this might ultimately help them in creating more value to the end-users of financial security trading. A similar argument underlies the findings by von Ungern-Sternberg (2004) on the efficiency of state-owned players in the European property insurance market.

<sup>8</sup>In a companion paper, see Van Cayseele (2005), we address the problem of competing platforms, building upon the recent literature on “two-sided markets”.

activities, increase. In a full fledged version of a translog cost function in two outputs and one input, also including a constant term, a dummy for ICSDs and a trend, one estimates 12 coefficients. Only one coefficient shows up to be significant at the 1% level, two others pass a 5% test while a final and last one satisfies a 10% level of significance.

Since Schmiedel et. al. only include one input variable, namely the gross domestic product per capita, which is used as a proxy for differences in labour costs across countries, there could be a problem of multicollinearity with one output variable, as we will indicate below. Moreover, per capita GDP is a quite general measure for input prices, and therefore we will try to sharpen measurement on the input side of the CSDs' allocation of resources problem.

As output variables, Schmiedel et. al. use the number of transactions settled in the system as a proxy for the settlement service, while the depository service is approximated by the value of securities held. Whenever stock valuations increase, there could be a multicollinearity problem. This will be the case when the increased value of the portfolio's held by the investors induces them to consume more, triggering a multiplier enhanced increase in GDP<sup>9,10</sup>. Moreover, whenever trading and hence settlement activity is influenced by "demand shocks" (increased GDP), also inputs will be affected, leading to endogeneity problems.

As a dependent variable, Schmiedel et. al. use costs which are measured by the operating expenses, in which depreciation and labour costs are included with "other expenditures". They include a dummy to indicate that an institution is an ICSD. In appendix B, we re-estimate the model of Schmiedel et. al. whereby we use our data set.

Many of the above critiques can be remedied by turning to appropriate estimation techniques. Especially the use of instrumental variables to overcome the endogeneity problem could be envisaged. However, we think the problems are mainly driven by misspecification rather than by the use an inappropriate econometric technique.

In the present study, we will use the total operating expenses including depreciation as well to approximate the costs that are made by a settlement institution. This

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<sup>9</sup>The so-called "real balance effect" has received much attention in the macro-economic literature, see Blanchard (2003)

<sup>10</sup>And vice versa, increases in GDP could signal permanent shifts in trend growth, leading to increased sales and profits. Since asset prices are determined as the sum of the discounted profits of the company, they will increase as GDP increases.

variable will be written as TC. In order to check for robustness, we sometimes also use Tc, which denotes total operating costs minus depreciation. The reason is that depreciation is very dependent on different fiscal regimes and practices. Yet, while a price of capital variable is not easy to find or construct, it is often included as a regressor in the translog cost function.

With respect to the input and output variables, there are some differences compared to the paper of Schmiedel et. al. To proxy output on the investor’s side (settlement of trades but also dividends and coupons paid), we use the number of clients of the CSD. This variable comes closest to the  $N$  used in the analytical approach followed above. As we know,  $N^2$  (in fact  $N(N - 1)$ ) is the size of the grid of the network for settling trades. We therefore conjecture that this variable truly is a cost driver and a proxy for output, rather than the actual number of securities settled. The reason is that it really does not matter for costs whether a server is hit 100 or 500 times per second in settling trades, but instead, whether it is linked to 200 versus 500 different clients and their accounts. The reason is that essentially manpower is needed to make the necessary links, monitor the system a.s.o.. In the remainder of this paper, this variable will be denoted as Clients.

For the variable that reflects the safekeeping and custody services from the settlement institutions we use the number of the securities that are held by a CSD and denote it by Sechold. Also here the reasoning is that to administer a security, i.e. to establish links between the company that has emitted it and its investors, manpower and programming is needed. Again, Sechold is closest to the “theoretical”  $M$  which was withheld as an output variable in the previous section.

In brief, we know that the value of the settlement and custody service offered by the CSD network is an increasing function of respectively  $N^2M$  and  $NM$ . Hence an increase in the grid size  $NM$  can be seen as an output for which customers are willing to pay. And normally then, these outputs also will be cost drivers. This approach is much in line with the recently advanced “output characteristics” approach to cost functions in the financial industry, see Humphrey, Willeson, Bergendahl and Lindblom (2003). Especially in “bookkeeping” type of activities, such as payment systems and settlement, the quality of the service is costly to a bank, not the volume of transactions.

For the input variables, we have chosen for two “prices”. The first one is labour costs, the second one is other costs. In the rest of the paper, they will be denoted

by  $Lc$  and  $Oc$  respectively. The data section below explains how every variable is measured.

## 3.2 A loglinear specification

Before discussing the widely used translog cost function, it is well known that the dual to an output maximisation problem with a Cobb-Douglas specification for the production function yields a cost function given by equation (1):

$$C = \left(\frac{\alpha + \beta}{\alpha}\right) \left(\frac{\alpha}{\beta}\right)^{-\frac{\alpha}{\alpha+\beta}} Lc^{\frac{\beta}{\alpha+\beta}} Oc^{\frac{\alpha}{\alpha+\beta}} \left(\frac{Q}{A}\right)^{\frac{1}{\alpha+\beta}} \quad (1)$$

where  $w$  and  $r$  denote respectively the labour price and the price of other costs,  $L$  is the amount of labour while  $K$  denotes the amount of other costs.  $Q$  represents the output variable, i.e. Clients or Sechold, and  $A$  is a constant.

We initially estimate the loglinear version of equation (1). Therefore, we rewrite this equation and take the natural logarithm to obtain:

$$\ln(C) - \ln(Oc) = \alpha_0 + \alpha_1 \ln\left(\frac{Lc}{Oc}\right) + \alpha_Q \ln(Q) \quad (2)$$

where  $\alpha_0 = \ln\left(\frac{\alpha+\beta}{\beta}\right) - \left(\frac{\alpha}{\alpha+\beta}\right) \ln\left(\frac{\alpha}{\beta}\right) - \left(\frac{1}{\alpha+\beta}\right) \ln A$ , while  $\alpha_1 = \frac{\beta}{\alpha+\beta}$  and  $\alpha_Q = \frac{1}{\alpha+\beta}$ . There are economies of scale if  $\alpha + \beta > 1$ , meaning that if we have economies of scale, the coefficient  $\alpha_Q < 1$ .

## 3.3 The translog cost function

### 3.3.1 Model specification

The cost function used thus has the following general form:

$$\ln(TC) = f[\ln(Clients), \ln(Sechold); \ln(Lc), \ln(Oc)] \quad (3)$$

Or total operating costs  $TC$  depend on the one hand on the vector of outputs, namely the number of clients (Clients) and the number of securities held by a CSD

(Sechold), and on the other hand on the vector of parameters, essentially input prices, that is labour cost (Lc) and other cost (Oc).

For the estimations, we start with an application of the widely used translog cost function. The translog cost function is based on the functional form that was developed by 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 inputs and other variables like time, which is not included in the model we specified. This type of cost function is also used to analyse the cost structure of the banking industry, see for instance Swank (1996) and Rezvanian and Mehdian (2002).

The particular specification of the translog cost function that we estimate is the following:

$$\begin{aligned}
\ln(TC) = & c + \alpha_1 \ln(Clients) + \alpha_2 \ln(Sechold) + \left(\frac{1}{2}\right) \beta_{11} [\ln(Clients)]^2 \\
& + \left(\frac{1}{2}\right) \beta_{22} [\ln(Sechold)]^2 + \beta_{12} \ln(Clients) \ln(Sechold) \\
& + \gamma_1 \ln(Lc) + \gamma_2 \ln(Oc) + \left(\frac{1}{2}\right) \delta_{11} [\ln(Lc)]^2 + \left(\frac{1}{2}\right) \delta_{22} [\ln(Oc)]^2 \\
& + \delta_{12} \ln(Lc) \ln(Oc) + \lambda_{11} \ln(Clients) \ln(Lc) \\
& + \lambda_{12} \ln(Clients) \ln(Oc) + \lambda_{21} \ln(Sechold) \ln(Lc) \\
& + \lambda_{22} \ln(Sechold) \ln(Oc) + \epsilon
\end{aligned} \tag{4}$$

where  $\epsilon$  is the error term.

One can also add factor share equations to the translog cost function. These equations are obtained by applying Shephard's lemma to the translog model. More specifically, we get the following:

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

$$\begin{aligned}
S_{Oc} &= \frac{\partial \ln(TC)}{\partial \ln(Oc)} \\
&= \gamma_2 + \delta_{22} \ln(Oc) + \delta_{12} \ln(Lc) + \lambda_{12} \ln(Clients) + \lambda_{22} \ln(Sechold)
\end{aligned} \tag{5}$$

In these share equations,  $S_{Lc}$  and  $S_{Oc}$  represent the share in the total costs of the input variables labour costs and other costs respectively. The shares are calculated as follows, whereby  $P_i$  stands either for labour or other costs, and  $X_i$  represents the optimal factor equations.

$$S_i = \frac{\partial \ln(TC)}{\partial \ln(P_i)} = \frac{P_i}{TC} \frac{\partial TC}{\partial P_i} = \frac{P_i X_i}{TC} \tag{6}$$

The fraction is the share of the i-th input variable in total cost. So,  $S_i$  is the proportion of the total costs that is absorbed by the i-th factor. The translog cost function in equation (4) will be estimated in section 5.2 using the Seemingly Unrelated Regression technique in which the factor share equations in (5) are added tot the system.

### 3.3.2 Economies of scale

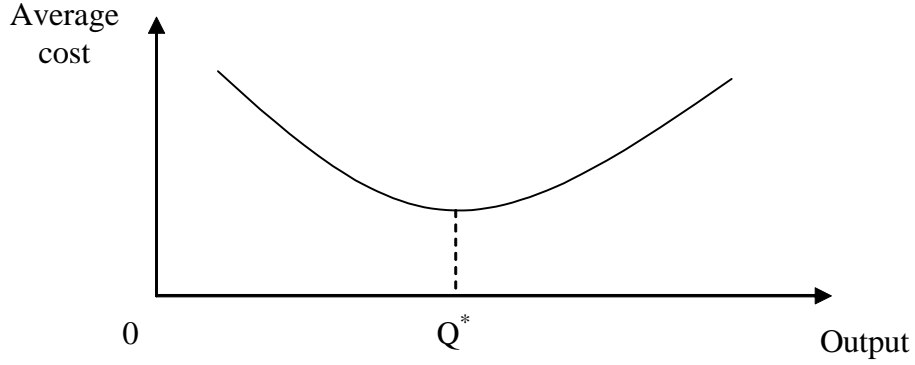
In order to have economies of scale, the average costs should decrease as the output of an institution increases. This is shown in figure 1.

For all points to the left of  $Q^*$ , the average cost will decrease if the output increases, indicating that there are economies of scale. The points to the right of  $Q^*$  are facing diseconomies of scale, since the average cost is increasing when the output is increasing. The optimal point  $Q^*$  is called the Minimum Efficient Scale. The average cost curve reaches its minimum in this point, and there are constant returns to scale.

Scale economies (SE) can be calculated as follows:

$$\frac{\partial \ln(TC)}{\partial \ln(Q)} = \frac{\partial TC}{\partial Q} \frac{Q}{TC} = \frac{MC}{AC} \tag{7}$$

Figure 1: **Economies of Scale**



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 (2), we obtain the following scale elasticity coefficients:

$$\begin{aligned}\varepsilon_{Clients} &= \frac{\partial \ln(TC)}{\partial \ln(Clients)} \\ &= \alpha_1 + \beta_{11} \ln(Clients) + \beta_{12} \ln(Sechold) + \lambda_{11} \ln(Lc) + \lambda_{12} \ln(Oc)\end{aligned}$$

$$\begin{aligned}\varepsilon_{Sechold} &= \frac{\partial \ln(TC)}{\partial \ln(Sechold)} \\ &= \alpha_2 + \beta_{22} \ln(Sechold) + \beta_{12} \ln(Clients) + \lambda_{21} \ln(Lc) + \lambda_{22} \ln(Oc)\end{aligned}\tag{8}$$

Here,  $\varepsilon_{Clients}$  and  $\varepsilon_{Sechold}$  are the scale elasticity coefficients with respect to the two output variables Clients and Sechold. 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:

$$SE = \sum_i \frac{\partial \ln(TC)}{\partial \ln(Q_i)} = \varepsilon_{Clients}(Clients, Sechold) + \varepsilon_{Sechold}(Clients, Sechold) \quad (9)$$

### 3.3.3 Economies of scope

In order to verify the existence of economies of scope, one has to verify the condition

$$\ln(TC(Clients, Sechold)) < \ln(TC(0, Sechold)) + \ln(TC(Clients, 0)) \quad (10)$$

Since the research conducted on the Bell system, see Rölller (1990a) and Rölller (1990b), it is well known that the translog cost function is not stable in view of verifying the scope property. The reason is that taking the logarithm of zero may introduce infinity in the approximation of the cost surface near the output axes.

It is easily seen that as one takes the limit of the estimated cost function as one output, say Clients goes to zero, costs will either tend to respectively zero or to infinity, depending on whether  $\beta_{11}$  is respectively smaller or larger than zero. And of course, the same remark holds for the estimate for  $\beta_{22}$ . If the cost surface near both of the axes approaches zero, it is impossible to conclude in favour of economies of scope, for any output combination involving positive amounts of clients and securities kept safe will entail positive costs, exceeding the sum of the two zeros. Conversely, if near the axes the cost function tends to infinity, scope economies will be “forced upon” the function.

This so-called “flip-flop” property of the translog cost function induces one to come up with different solutions to investigate the existence of economies of scope, that is to document the inefficiencies that will result from breaking up a system of integrated settlement and safekeeping. One possibility, already put forward in Rölller (1990a), consists of estimating a constant elasticity of substitution - quadratic cost function. We will follow this approach also here and estimate a “CES-Q” cost function, see below.

Another possibility, which will be exploited first, is to stay with the translog cost function specification, but to estimate a restricted version. In particular, to

restrict the second order output effects to be zero. This has a number of implications. The first is that we impose constant returns to scale throughout the range of observations. More importantly, in view of detecting the existence of synergies in combining services to investors and emittents, we impose diseconomies of scope. This can easily be seen from noting that  $\ln(Tc(0, Sechold))$  and  $\ln(Tc(Clients, 0))$  both tend to zero as *Sechold* and *Clients* tend to zero. Hence, whenever we observe a (statistically significant) negative coefficient on the interaction term of both output dimensions ( $\ln(Clients) \times \ln(Sechold)$ ), this points towards cost advantages resulting from jointly performing settlement and safekeeping, despite the fact that overall diseconomies of scope have been enforced upon the translog cost function system of equations.

Or to put it still in another way, one could argue that one picks the specification which overall is worst for economies of scope to exist, to investigate the possibility of such economies near the expansion path, for this is what the interaction term  $\ln(Clients) \times \ln(Sechold)$  measures in a first order Taylor expansion in logarithms.

### 3.4 The CES-Q cost function

A more sophisticated approach to investigate the existence (and magnitude) of economies of scope can be taken by estimating a CES-Q cost function. The particular specification of the CES-Q function that is estimated is:

$$\begin{aligned}
C^{CES-Q}(Clients, Sechold; Lc, Oc) &= [\gamma_1 Lc^{-r} + \gamma_2 Oc^{-r}]^{(-1/r)} * \\
& [c + \alpha_1 Clients + \alpha_2 Sechold \\
& + \left(\frac{1}{2}\right) \beta_{11} Clients^2 + \left(\frac{1}{2}\right) \beta_{22} Sechold^2 \\
& + \beta_{12} Clients * Sechold] \tag{11}
\end{aligned}$$

The parameter  $r$  is to be estimated as an indication of the substitution possibilities a CSD has. Since (11) is nonlinear, it has to be estimated using a maximum likelihood method. A disadvantage of the CES-Q function is that it imposes strong separability between outputs and input variables, see Pulley and Braunstein (1992). For the moment, given the limited number of data points, we did not test for this restriction.

Once estimated, there are no problems to analyse the existence of scope economies, as can be readily seen from noting that:

$$C^{CES-Q}(0, Sechold; Lc, Oc) = [\gamma_1 Lc^{-r} + \gamma_2 Oc^{-r}]^{(-1/r)} * \left[ c + \alpha_2 Sechold + \left(\frac{1}{2}\right) \beta_{22} Sechold^2 \right] \quad (12)$$

and

$$C^{CES-Q}(Clients, 0; Lc, Oc) = [\gamma_1 Lc^{-r} + \gamma_2 Oc^{-r}]^{(-1/r)} * \left[ c + \alpha_1 Clients + \left(\frac{1}{2}\right) \beta_{11} Clients^2 \right] \quad (13)$$

## 4 Data

### 4.1 Data collection

The data that are used to perform the estimations in the next sections are collected from a variety of publications. The largest part of the data was collected from the annual reports of the CSDs. Especially concerning the retrieving of data regarding labour costs, other costs and total costs, annual reports provided the primary source. Also the internet sites of the settlement institutions proved to be an important source in the construction of the data set. Additional information was obtained 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. Finally, information was also given by some settlement institutions. They provided us with data from annual reports for years not available on their website anymore.

In the paper of Schmiedel et. al., not only European CSDs and ICSDs are included, but also institutions from the United States and Asia. However, since the focus of our paper concerns the European settlement industry, only settlement institutions of European countries are included.

Finally, a number of annual reports were expressed in euro. Nevertheless, there were some annual reports in the local currency, like in the United Kingdom, Denmark, Sweden, Norway and Switzerland. Also, some older annual reports are still expressed in local currency. To convert the numbers from these annual reports to one single currency, namely the euro, the exchange rates at the end of each year were used.

Table 1 gives an overview of the settlement institutions that are included in the data set, as well as the respective annual reports. In total we have 31 annual reports in our dataset. The years covered range from 1997 to 2004. As can be seen, the two European ICSDs, namely Euroclear and Clearstream, are not included in our sample. The reason for this is that we did not have accurate data for the output variables Clients and Sechold for both ICSDs. Moreover, would one have the data, one still could ask whether they should be included in the present contribution, since the nature and size of their activities brings them closer to other operators in the industry, like the U.S. CSD. A similar remark does not hold for Sisclear - SegalInterSettle who is much more at the size of the other “national” European CSDs.

Table 1: **Sample of Settlement Institutions**

<b>Settlement institution</b>	<b>Country</b>	<b>CSD/ICSD</b>	<b>Annual reports</b>
Crestco	United Kingdom	CSD	1997-2002
CSD	Greece	CSD	2002
Interbolsa	Portugal	CSD	2000-2002
Monte Titoli	Italy	CSD	1998-2002
VP	Denmark	CSD	1999-2002
VPC	Sweden	CSD	2002-2004
VPS	Norway	CSD	2000-2004
Sisclear - SegalInterSettle	Switzerland	CSD/ICSD	2001-2004

## 4.2 Descriptive statistics

Table 2 gives the descriptive statistics for each of the main variables used in the regressions. The mean of every input and output variable as well as total cost is given, together with their median, standard deviation and their minimum and maximum value.

Table 2: **Descriptive Statistics**

	<b>TC</b>	<b>Lc</b>	<b>Oc</b>	<b>Clients</b>	<b>Sechold</b>
Mean	40119834	13464012	21895690	5522	18205
Median	22211014	10592515	9435331	893	5018
Std. Dev.	33708352	10151643	20959193	12839	25548
Maximum	112151191	44456133	63716607	52881	87076
Minimum	7176137	2129481	4148382	43	353
Skewness	1.0616	1.7281	0.9973	2.7982	1.7428

As can be seen from the results of the maximum and minimum values in table 2, sometimes large differences are present. This is mainly due to differences in the scale of the CSDs in our sample. For instance, the U.K. and Swiss CSD have much more investors and emittents than the Greek or Portuguese CSD. Moreover, there is a quite large gap between the mean and the median, again because of this reason. This also shows from the skewness, which is a measure for the asymmetry of the distribution of the series around its mean. The skewness of a symmetric distribution, such as the normal distribution, is zero. Positive skewness means that the distribution has a long right tail. This is clearly the case in our sample. Therefore, it sometimes is more convenient to use the median. In this way the effect of outliers becomes less important, and from the standard deviations and the minimum and maximum values of the output variables, it can be seen that there are indeed some outliers in our sample. This will be important for the calculation of the economies of scale in section 5.3.

### 4.3 Average costs

A first indication for the cost efficiency of settlement institutions can be derived from the cost per unit of output. Like explained before, we have two measures for the output of a settlement and safekeeping institution, namely the number of clients and the number of securities held by the CSD . The average costs in Euro are displayed in the table 3.

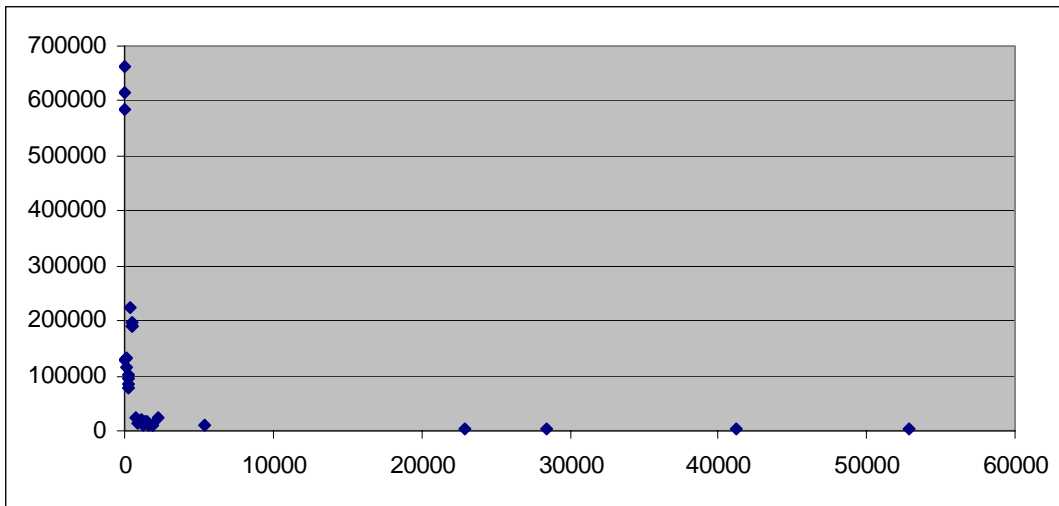
It is remarkable that the average cost per client is quite diverse. This might be explained by the concentration ratio in retail banking. The higher this ratio is in a

Table 3: Average Costs

Settlement Institution	TC/Clients (*10 <sup>3</sup> )	TC/Sechold (*10 <sup>3</sup> )
Crestco	3.107	6.178
CSD	22.163	50.603
Interbolsa	125.510	4.882
Monte Titoli	10.470	0.621
VP	88.965	6.788
VPC	618.541	5.364
VPS	16.989	5.847
Sisclear	200.112	1.189

particular country, the lower the number of financial institutions which are a client of a CSD. As a result, the average cost per client will go up. The variety in average costs can also be seen when we plot the average cost of all data points against the number of clients. This is done in figure 2. On the horizontal axis, we have the number of clients, while on the vertical axis, the average cost per client is given. As can be seen, the average cost goes down quite rapidly as the number of clients increases.

Figure 2: Average cost per client

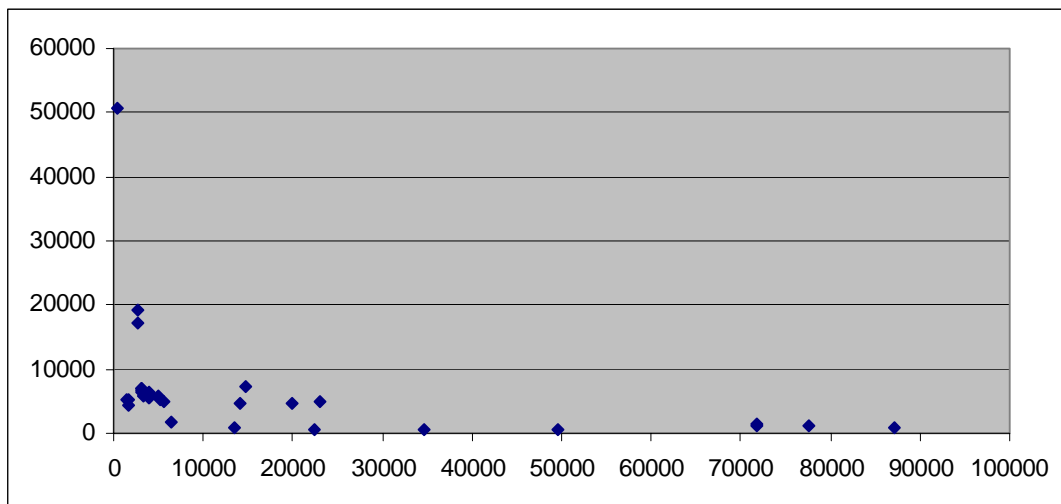


Concerning the average cost for the number of securities that are held in custody,

it is clear from table 3 that the CSDs seem to be more or less equally cost efficient. There is however one outlier, namely the Greek CSD. The very high value for this institution stems from the low number of securities that are held by this CSD. This can also be seen in table 2 where the minimum value of Sechold is that of the Greek CSD. In general, we can say that the larger the number of securities held, the lower the average cost is, up to a certain level for which the average cost stays more or less constant.

This can also be seen in figure 3, which plots the average cost of keeping one security in custody against the number of securities held in safekeeping. As becomes clear, the average cost again decreases rather quickly with the number of the securities held and stays more or less constant from a level of securities holdings of approximately 25000 securities.

Figure 3: **Average cost for keeping one security in custody**



When we compare the figures 2 and 3 of the average costs with figure 1, we can see that the minimum efficient scale for the number of clients is reached very quickly, namely for around 1500 clients, while the minimum efficient scale for the number of securities held is around 25000 securities. Since the minimum efficient scale expresses the value for the output at which an institution operates in the most efficient way, these are the values of output that a CSD minimally should attain. And as a consequence, these values can be used to determine how many CSDs there should

be in Europe. From our data, only two CSDs have values beyond both these cut-off rates.

## 5 Estimation results

In this section, we estimate the translog cost function model described in section 3.2. But first, we do some simple regressions to verify whether the output variables that are used in the analysis, namely the number of clients that hold an account and the number of assets held in custody, are valid cost drivers, i.e. that more output (as measured by Clients and Sechold) induce more costs.

### 5.1 Some basic regressions

We start the analysis with a series of regressions using a loglinear specification for total costs. The output variables that we intend to use (Clients and Sechold) are exclusively and jointly regressed on the total cost variable. The results can be found in table 4. The regressions in this table are done using OLS. The t-values are reported in parenthesis. The models 1a, 1c and 1e are estimated using TC, while for the models 1b, 1d and 1f, Tc was used. From the table, it is clear that both output variables are significant cost drivers that can be used in the rest of the analysis.

Table 4: Totals costs regressed on output variables

Explanatory variables	Model 1a estimates	Model 1b estimates	Model 1c estimates	Model 1d estimates	Model 1e estimates	model 1f estimates
c	15.6754 (34.91)	15.7867 (34.03)	13.8781 (17.81)	13.6872 (18.38)	13.4684 (18.78)	13.3810 (18.55)
ln(clients)	0.2254 (3.49)	0.1912 (2.87)			0.1590 (2.78)	0.1188 (2.07)
ln(sechold)			0.3704 (4.29)	0.3787 (4.59)	0.2972 (3.62)	0.3239 (3.92)
R <sup>2</sup>	0.2963	0.2212	0.3882	0.4207	0.5205	0.4973
Included observations	31	31	31	31	31	31

In order to come to the full translog model in the next section, we further estimate some models whereby we include one or two variables step by step. First, in model 2 we include the interaction term between the two output variables. Subsequently, we include the two input variables in model 3, namely  $Lc$  and  $Oc$ . The labour price  $Lc$  is obtained by dividing the total labour cost in one year by the number of employees. Both numbers can be found in the annual reports. However, since the price of other costs is hard to determine, we use the ratio of GDP relative to a fixed base year as a proxy. In particular, we took the beginning of 1995 as our base year for GDP in every country, and then divided every end of year value by this initial number. Finally, we also estimate model 4, where the interaction term between  $Lc$  and the GDP ratio is added. The results can be found in table 5. Model a denotes the estimations with the TC variable, while model b is estimated using  $Tc$ .

Table 5: **Estimation of input and output variables**

<b>Explanatory variables</b>	<b>Model 2a estimates</b>	<b>Model 2b estimates</b>	<b>Model 3a estimates</b>	<b>Model 3b estimates</b>	<b>Model 4a estimates</b>	<b>model 4b estimates</b>
c	8.8436 (2.49)	9.1812 (2.56)	-0.8244 (-0.25)	-0.2271 (-0.07)	-21.7789 (-2.62)	-19.7612 (-2.35)
$\ln(\text{clients})$	0.8921 (1.61)	0.7846 (1.40)	0.3981 (1.05)	0.2787 (0.74)	0.5543 (1.61)	0.4243 (1.22)
$\ln(\text{sechold})$	0.8166 (2.04)	0.7957 (1.97)	0.2767 (0.98)	0.2433 (0.87)	0.3800 (1.49)	0.3395 (1.32)
$\ln(\text{clients}) * \ln(\text{sechold})$	-0.0812 (-1.33)	-0.0737 (-1.19)	-0.0316 (-0.76)	-0.0234 (-0.56)	-0.0479 (-1.27)	-0.0386 (-1.01)
$\ln(lc)$			1.3764 (5.20)	1.3717 (5.22)	3.1363 (4.52)	3.0124 (4.29)
$\ln(\text{gdpratio})$			-1.7848 (-3.36)	-1.9548 (-3.72)	50.7169 (2.60)	46.9879 (2.39)
$\ln(lc) * \ln(\text{gdpratio})$					-4.6335 (-2.70)	-4.3194 (-2.49)
$R^2$	0.5500	0.5225	0.8133	0.8093	0.8567	0.8484
Included observations	31	31	31	31	31	31

Model 4 estimates already explain a lot of the variation in the dependent variable, while still restricting the model to be linear. As explained, this “enforces” constant returns to scale and diseconomies of scope. Nonetheless, the coefficient of the interaction term  $\ln(\text{Clients}) * \ln(\text{Sechold})$  shows up with a negative sign, although it is not statistically significant. This indicates that near the expansion path ray, cost efficien-

cies are obtained from including both the settlement and the safekeeping functions in the range of activities performed by a CSD. The next section will explore the validity of restricting the second order effects to be zero.

Before we report the results of the full translog cost model, we first estimate the loglinear model of equation (2). The estimation results are given in table 6. The variable TC is used for the estimation of models A, C, E and G, while for the other models Tc is used. One however has to keep in mind that the dependent variable in table 6 is the difference between the natural logarithms of the cost variable and the GDP ratio which as mentioned above is used as a proxy for the price of other costs. We start with simple regressions including only one output variable in the models A through D. Subsequently, we include both of them in the models E and F, and we finally add the interaction term between both output variables in the last two models.

First of all, the results from tables 4 and 5 are confirmed. More in particular, the estimations of models A to D indicate that economies of scale for both Clients and Sechold are present, since the estimated coefficient  $\alpha_Q$  is smaller than one for both outputs. Also, the scale economies with respect to the number of securities held seems to be larger, since the estimated coefficient is smaller. Moreover, when we include the interaction term  $\ln(Clients) * \ln(Sechold)$ , the estimated coefficient of this term is negative as was the case in table 5, suggesting again that cost efficiencies can be obtained when a CSD is active in both settlement and safekeeping.

## 5.2 Estimation of the translog cost function

In this section, we report the estimations for the full translog cost model as described in equation (4). We include the share equations (5) for labour as well as for other costs. In model 5 we present the estimation results of the translog model using the Seemingly Unrelated Regression (SURE) technique proposed by Zellner (1962). The model is first estimated with a single share equation. Subsequently, in model 6, we add the other share equation to the model and re-estimate it, again using SURE . The advantage of this method is that the estimations are asymptotically equivalent to the maximum likelihood estimation. Given the fact that we only have data for eight institutions and for a limited number of years, the use of share equations also is justified by efficiency reasons, as the technique increases the degrees of freedom. The results are given in table 7. Like before, t-values are reported in parenthesis,

Table 6: Estimation of some loglinear models

<b>Explanatory variables</b>	<b>Loglinear Model A estimates</b>	<b>Loglinear Model B estimates</b>	<b>Loglinear Model C estimates</b>	<b>Loglinear Model D estimates</b>
c	-4.4314 (-1.89)	-5.0041 (-2.07)	-4.0433 (-1.37)	-4.0032 (-1.46)
ln(clients)	0.1572 (3.79)	0.1193 (2.78)		
ln(sechold)			0.1443 (1.76)	0.1565 (2.04)
ln(clients)*ln(sechold)				
ln(lc/gdpratio)	1.8600 (8.38)	1.9253 (8.40)	1.8025 (5.90)	1.7780 (6.23)
R <sup>2</sup>	0.8048	0.7857	0.7341	0.7620
Included observations	31	31	31	31

<b>Explanatory variables</b>	<b>Loglinear Model E estimates</b>	<b>Loglinear Model F estimates</b>	<b>Loglinear Model G estimates</b>	<b>Loglinear Model H estimates</b>
c	-3.0494 (-1.22)	-3.2838 (-1.30)	-4.4521 (-1.36)	-4.3045 (-1.29)
ln(clients)	0.1467 (3.54)	0.1062 (2.52)	0.4244 (1.02)	0.3082 (0.73)
ln(sechold)	0.0999 (1.42)	0.1243 (1.74)	0.3013 (0.98)	0.2709 (0.86)
ln(clients)*ln(sechold)			-0.0306 (-0.67)	-0.0223 (-0.48)
ln(lc/gdpratio)	1.6571 (6.36)	1.6728 (6.32)	1.6205 (6.03)	1.6461 (6.00)
R <sup>2</sup>	0.8184	0.8074	0.8215	0.8091
Included observations	31	31	31	31

while both the coefficient of determination of the translog cost function and the share equations estimated are given.

When including the squared output terms, it becomes clear that we cannot restrict the attention to a linear system. Both the coefficient of  $(\ln(Clients))^2$  and  $(\ln(Sechold))^2$  are positive and statistically significantly different from zero. This implies that as one investigates whether economies of scope are present, an indeterminacy results and it is impossible to reach a proper conclusion along this way.

On the other hand, it should be noted that for each of the regressions, the coefficient of the interaction term  $\ln(Clients) * \ln(Sechold)$  is negative, as before. But now it is statistically significant, often even at the one tenth of a percent level. Hence, along the expansion ray of outputs, the joint production of settlement and safekeeping activities clearly leads to efficiency gains.

Models 7 and 8 repeat the regression of models 5 and 6, but now using the adjusted total cost (excluding depreciation). The conclusions remain the same. Model 8 includes all the share equations for the problem (one assumes production of outputs mainly uses two inputs, labour and the “other production factor”). It is a complete translog cost function estimate, imposing the full implications of duality theory upon the system, and hence it constitutes the preferred equation.

With a very limited number of observations, we succeed in estimating 15 coefficients, of which 5 are statistically significant at the 1% level or below. Still others are significant at the 10% level. The coefficients for both outputs have the appropriate sign. This conclusion also holds for one of the input prices, viz. labour cost.

### 5.3 Economies of scale

We calculate the economies of scale for each of the output factors, as well as the sum of both, by estimating the scale elasticities specified in equation 8 at the sample mean as well as at the median. However, as mentioned before, the mean is somewhat biased towards the large CSDs. Therefore, the median is a more appropriate measure, and only the estimation results for the median are reported. The scale elasticity coefficients are calculated by applying the estimated coefficients from model 6 in table 7 to the equations of the scale elasticities in (8), whereby we use the median as the number for the input and output variables.

Table 7: Estimation of the translog cost function

Explanatory variables	Model 5 estimates	Model 6 estimates	Model 7 estimates	Model 8 estimates
c	4.8661 (0.88)	-0.5781 (-0.12)	4.8558 (0.86)	-0.8174 (-0.17)
ln(clients)	1.2164 (2.35)	1.4154 (5.04)	1.1805 (2.19)	1.3257 (4.45)
ln(sechold)	0.2828 (0.43)	0.3783 (0.74)	0.2379 (0.35)	0.4501 (0.82)
(ln(clients)) <sup>2</sup>	0.1830 (4.68)	0.2506 (8.04)	0.1709 (4.20)	0.2514 (7.55)
(ln(sechold)) <sup>2</sup>	0.1666 (2.78)	0.2041 (4.30)	0.1642 (2.62)	0.1962 (3.88)
ln(clients)*ln(sechold)	-0.2402 (-5.30)	-0.3106 (-7.44)	-0.2276 (-4.82)	-0.3059 (-6.86)
ln(lc)	0.5798 (0.93)	1.3270 (1.92)	0.6125 (0.98)	1.3471 (1.95)
ln(gdpratio)	-0.8952 (-0.18)	-0.1868 (-0.33)	-0.5446 (-0.10)	-0.1873 (-0.33)
(ln(lc)) <sup>2</sup>	-0.0522 (-0.88)	-0.0800 (-1.15)	-0.0555 (-0.94)	-0.0817 (-1.17)
(ln(gdpratio)) <sup>2</sup>	9.3843 (2.05)	-0.3873 (-4.55)	9.6240 (2.02)	-0.3827 (-4.53)
ln(lc)*ln(gdpratio)	0.5601 (4.66)	0.0877 (1.54)	0.5618 (4.67)	0.0872 (1.52)
ln(clients)*ln(lc)	-0.0038 (-0.41)	-0.0173 (-1.63)	-0.0036 (-0.39)	-0.0172 (-1.62)
ln(clients)*ln(gdpratio)	-0.5287 (-1.26)	-0.0269 (-2.93)	-0.6567 (-1.50)	-0.0268 (-2.92)
ln(sechold)*ln(lc)	0.0243 (1.62)	0.0056 (0.32)	0.0246 (1.63)	0.0054 (0.31)
ln(sechold)*ln(gdpratio)	-0.6057 (-1.67)	0.0027 (0.18)	-0.5719 (-1.51)	0.0032 (0.21)
R-squared	0.9222	0.8842	0.9125	0.8630
R-squared share Lc	0.5038	0.2188	0.5038	0.2178
R-squared share Oc		0.4701		0.4675
Included observations	31	31	31	31

Sometimes it is useful to consider the economies of scale along an expansion path. This can for instance be done by regressing the two output variables on each other. The result of this estimation of the loglinear expansion path, namely  $\ln(Clients) = f(\ln(Sechold))$  can be found in appendix C. Thus, the median values of Clients for each group are forecasted by this expansion path. The results for the economies of scale can be found in table 8 below. Q1 are the smallest institutions, while Q4 are the largest ones. The division occurred on the basis of the number of securities held by an institution. The t-statistics are denoted between parentheses to indicate whether an elasticity is significantly different from one. They were calculated by evaluating the elasticities on each observation, and then taking the standard error of these elasticities for each group of institutions.

Table 8: **Economies of scale**

	$\varepsilon_{Clients}$	$\varepsilon_{Sechold}$	SE
Q1	0.3596 (4.47)	0.1099 (19.67)	0.4695 (5.42)
Q2	0.3122 (23.11)	0.1485 (82.15)	0.4608 (27.09)
Q3	0.3811 (9.12)	0.2242 (22.32)	0.6053 (10.35)
Q4	0.5699 (13.55)	0.3250 (21.93)	0.8949 (6.43)

It is clear from table 8 that the extent to which there are economies of scale varies between institutions, and also between the output variable that is considered. There seems to be a larger potential for cost savings in unit costs for the number of securities held than for the number of clients. This confirms the findings of the estimation of the loglinear cost function in table 6, where we also found that the scale economies with respect to Sechold were larger.

Clearly, there exist larger economies of scale for the smallest institutions for both output variables. The somewhat higher values for Q4 can be explained by the presence of the Swiss CSD in this group, which also acts as an ICSD. The largest institutions however still can exploit economies of scale, but to a lesser extent than the smaller ones. In addition, the overall scale elasticities are higher for the larger institutions, but even for the largest institutions, substantial cost savings can be obtained. Therefore,

further horizontal consolidation is to be expected, for it will help some of the smaller CSDs to reach the scale that is necessary to exploit all efficiencies in production, necessary to guarantee their survival in the long run.

From the t-statistics in table 8, it is clear that all scale elasticities, and even the sum of both, are significantly different from one at the one percent level. The scale elasticities with respect to the number of securities held are even highly significant. The lower t-statistics for Q1 can be explained by the presence of two observations of Crestco in this group. The larger scale of this institution compared to the other institutions that are present in this group gives rise to a higher standard error, thus resulting in a lower t-statistic.

## 5.4 Economies of scope

In this section, we present the estimates of the CES-Q cost function. As argued, this specification is more suitable for investigating the existence of economies of scope. In estimating a CES-Q cost function, a full information maximum likelihood technique is used. In model 9, we use TC as the total cost variable, while in model 10 Tc is used. We start from a homogeneity parameter  $r$  equal to 1, and obtained convergence after 157 iterations for model 9, and after 93 iterations for model 10. Several starting values of  $r$  in the range from  $r = 0.4$  to  $r = 1.5$  yield approximately the same results. Yet, the coefficients are not unique because the covariance matrix is singular, and no t-statistics can be reported. The estimation results are given in table 9.

From an economic viewpoint, the results are without any doubt sensible. All input prices and outputs are very much in line with those obtained from the translog cost function specification. More in particular, the scale economies that were found to exist for Clients and Sechold are confirmed, as can be seen from the negativity of the coefficient. In addition, efficiency gains from the joint production of settlement and safekeeping are found, as can be seen from the negative coefficient with the interaction term of Clients and Sechold. The magnitude of the coefficient suggest that when a CSD with 2000 clients and 5000 securities held is broken up in a separate safekeeping and settlement institution, costs will increase by at least three to five percent if one adds together the operating costs of the separate institutions.

Table 9: Estimation of the CES-Q cost function

<b>Explanatory variables</b>	<b>Model 9 estimates</b>	<b>Model 10 estimates</b>
c	153.2037	16.8159
Clients	7219.7900	5513.3200
Sechold	1860.4460	1538.7840
Clients <sup>2</sup>	-0.1564	-0.1189
Sechold <sup>2</sup>	-0.0111	-0.0618
Clients*Sechold	-0.0687	-0.0069
Lc	4071.9010	1530.5350
gdpratio	0.4782	0.4761
r	0.7421	0.6668
R <sup>2</sup>	0.7813	0.7518
Log Likelihood	-557.2522	-554.8996
Included observations	31	31

## 6 Conclusion

The efficiency of the European clearing, settlement and safekeeping industry recently came into the public debate. Compared to the US, some argue, the European scene is very expensive, especially if one wants to settle across the border. To make this point, some have illustrated what it costs to an investor to settle a transaction. This of course is misleading, since seldomly one obtains an insight regarding the efficiency of a company by focussing on its revenues rather than its costs. One even could say that the debate here has confused the elementary economic distinction between technical and allocative efficiency.

Hence, in order to properly investigate whether an industry operates at the frontier of its possibilities, one needs to estimate a cost function, and this approach was followed here. The findings indicate that especially the smaller institutions still can realize many scale economies. This constitutes a rationale for further consolidation. Even the larger operators in the sample have still potential for growing along a cost reducing path.

The empirical results together with some insights from theory regarding the bundling of one with two way networks points towards the existence of economies of scope. This means that separating settlement from safekeeping services, and hosting them in different entities will entail efficiency losses and cost increases. Very few is known on the

bundling of different types of economic networks, and hence, until more theory and evidence provides us with clearer insights, one should not implement easy regulatory or antitrust solutions like the unbundling of activities, as was done in some other sectors. Our findings clearly point toward the existence of economies of scope, and hence separating the different operations performed within a CSD only would lead to cost increases for the economy.

In order to obtain additional insights into the performance of the settlement and safekeeping industry, the present study could be extended. Our findings could equally hold for other players who perform safekeeping and settlement activities, such as local agent banks. Hence they might be included in the sample. But then we would need detailed data on the outputs, like the number of client accounts, volumes of securities settled on their books, a.s.o. Ideally, a study of this type would jointly include CSDs, local agent banks and global custodians in the sample. This might be a topic for future research.

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## Appendix A: Concentration of retail banking decreases transactions settled

In this appendix, we document a negative correlation between the concentration ratio (CR) in the downstream industry, viz. banking sector, and the number of transactions settled (Transet) by the CSD. When local agent banks settle more transactions on their own books, which becomes possible because the sector is more concentrated, less business is left for the CSD. When the banking sector would create settling bridges between all banks, CSDs would be “foreclosed” entirely.

Usually foreclosure is reserved to describe a situation where an upstream firm denies access to an essential input to a downstream rival of his affiliated company, but downstream firms can equally shortcut upstream companies, see also Van Cayseele (2004). In their recent analysis of foreclosure, Rey and Tirole (2003) claim that this situation is even worse for competition than the more “classical” situation which deprives a downstream firm.

The statistically significant negative coefficient of downstream concentration indicates the possibility of such behavior, partially taking place. But further research should verify whether CR remains a negative predictor for business volume when other explanatory factors are taken into account, so as to ensure that CR does not pick up country-specific effects.

Table 10: **Concentration ratio**

Dependent Variable: ln(Transet)	
Explanatory variables	Coefficient Estimates
c	17.1729 (32.21)
CR	-1.9861 (-1.88)
R-squared	0.1442
Included observations	23

## Appendix B: Estimating the translog cost function with alternative output variables

In this appendix, we estimate the translog model whereby we take the variables that Schmiedel et. al. use in their paper as regressors. More in particular, the number of transactions settled by a CSD (*Transet*) proxies the settlement service, while for the custody activities, the value of the securities held (*Cust*) is used. As indicated before, the Schmiedel et. al. only use one input variable, namely the gross domestic product per capita (*GDPcap*). A dummy variable (*ICSD*) is added to indicate whether an institution is an ICSD or not since the two European ICSDs are included in the sample. Thus, the following model is estimated.

$$\begin{aligned}
 \ln(TC) = & c + \alpha_1 \ln(Transet) + \alpha_2 \ln(Cust) + \left(\frac{1}{2}\right) \beta_{11} [\ln(Transet)]^2 \\
 & + \left(\frac{1}{2}\right) [\beta_{22} \ln(Cust)]^2 + \beta_{12} \ln(Transet) \ln(Cust) \\
 & + \gamma \ln(GDPcap) + \delta [\ln(GDPcap)]^2 + \lambda_1 \ln(Transet) \ln(GDPcap) \\
 & + \lambda_2 \ln(Cust) \ln(GDPcap) + \mu ICSD
 \end{aligned} \tag{14}$$

Schmiedel et. al. do not include the share equations when they estimate their model. Hence, equation (14) is estimated using OLS. They obtain a negative coefficient for both output variables, their squared terms and the input variable, while a positive coefficient shows up for the interaction term of *Transet* and *Cust*. The results for the estimation of equation (14) whereby our data set is used can be found in table 11.

As can be seen, more observations are used to estimate equation (14) than for the estimations of the translog cost function in equation (4), since more information is available with respect to *Transet* and *Cust* than to *Clients* and *Sechold*. From table 11, it can be seen that the estimated coefficients of the output variables and that of the input variable is negative, as in Schmiedel et. al. Moreover, the interaction term between  $\ln(Transet)$  and  $\ln(Cust)$  is positive. However, contrary to the estimation results of Schmiedel et. al., the squared output terms are positive. Finally, a negative coefficient is estimated for the *ICSD* dummy, while this dummy was positive in the paper of Schmiedel et. al.

Table 11: Estimation of an alternative translog cost model

Explanatory variables	Coefficient Estimates
c	177.8366 (6.89)
ln(transet)	-1.4741 (-1.47)
ln(cust)	-10.8666 (-4.30)
(ln(transet)) <sup>2</sup>	0.0887 (0.61)
(ln(cust)) <sup>2</sup>	0.1027 (1.03)
ln(transet)*ln(cust)	0.0502 (0.56)
ln(GDPcap)	-2.8686 (-0.50)
(ln(GDPcap)) <sup>2</sup>	-1.4025 (-1.99)
ln(transet)*ln(GDPcap)	-0.0973 (-0.61)
ln(cust)*ln(GDPcap)	0.7401 (7.38)
ICSD	-1.5100 (-4.19)
R-squared	0.9860
Included observations	53

## Appendix C: Estimating the expansion path

In this appendix, we regress one output variable on the other. The estimated coefficients are used to forecast the values of  $\ln(\text{Clients})$  when calculating economies of scale in section 5.3 according to equation (8).

Table 12: Estimation of linear logarithmic expansion path

Dependent Variable: $\ln(\text{Clients})$	
Explanatory variables	Coefficient Estimates
c	2.5769 (1.13)
$\ln(\text{Sechold})$	0.4606 (1.82)
R-squared	0.1029
Included observations	31