LISBON SCHOOL OF ECONOMICS & MANAGEMENT
UNIVERSIDADE DE LISBOA

MASTER OF SCIENCE IN FINANCE

Master's Final Work
THESIS

OTC MARKETS – CLEARING, SETTLEMENT & CUSTODY ANALYSIS

"A COST FUNCTION ESTIMATION OF CENTRAL SECURITIES DEPOSITORIES (CSDS)"

JOÃO PEDRO MACHADO NÓBREGA

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ORIENTATION:
PROFESSOR MARIA TERESA MEDEIROS GARCIA

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Resumo

Este trabalho analisa a eficiência dos Sistemas Centralizados de Valores Mobiliários (*Central Securities Depositories* (CSDs)) em relação aos custos, na Europa. As CSDs são organizações financeiras especializadas na guarda de títulos até à sua data de liquidação. A abordagem adotada assenta na estimação de custos que permita comparar a eficiência das instituições em análise. Também é analisado o impacto do programa *Target2 - Securities* (estabelecido pelo BCE) e do regulamento CSDR concebido para estas instituições. O primeiro tem como objetivo contribuir para remoção de barreiras à eficiência de custos na liquidação entre mercados financeiros, e o último a promoção da segurança, eficácia e competitividade dos mercados financeiros da UE. Por último, procura-se saber se existem economias de escala para cada CSD, dependendo do seu tamanho e país.

Palavras Chave: Liquidação Transfronteiriça, Eficiência de Custo, Função de Custo Translog, Sistemas Centralizados de Valores Mobiliários (CSDs) & ICSDs, Economias de Escala.

Classificação JEL: L14, G20, F36, C51, F14

Abstract

This work is based on the analysis of cost efficiency on European Central Securities Depositories (CSD's). These financial institutions are experts on holding securities and clearing them until its settlement date. Our approach is focused on cost estimation, in order to compare the efficiency of each institutions analyzed. In addition, we examine the impact of ongoing Target2 - Securities program (by the ECB) as well as the impact of the CSDR regulation made for these institutions. The first is a new European securities settlement engine that aims to contribute for removing the barriers for poor cost efficiency on cross-border settlement between financial markets, and the latter aims to promote the safety, effectiveness and competitiveness of the EU financial markets. Furthermore, the main objective is to find out if economies of scale exists for each CSD, depending on its size and country.

Keywords: Cross border Settlement, Cost Efficiency, Translog Cost Function, European Central Securities Depositories (CSDs) & ICSDs, Economies of Scale.

JEL classification : L14, G20, F36, C51, F14

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Glossary

BCE – Banco Central Europeu

C&S – Clearing and Settlement

CCP – Central counterparty clearing house

CSD – Central securities depository

CSDR – Central Securities Depositories Regulation

DVP – Delivery versus Payment

ECB – European Central Bank

ECSDA - European Central Securities Depositories Association

FMA - The Financial Markets Authority

GAAP - Generally Accepted Accounting Principles

ICSD – International central securities depository

IFRS – International Financial Reporting Standard

JEL – Journal of Economic Literature

MLE - Maximum Likelihood Estimation

OLS – Ordinary Least Squares

OTC – Over the Counter

STP – Straight Through Processing

SUR - Seemingly Unrelated Regression

T2S – TARGET2-Securities

U.S.A. – United States of America

Introduction

Cross-border security settlements around Europe are nowadays facing difficulties on cost efficiency and competition, but measures are currently under way. The ECB and other market regulatory institutions are struggling to improve the competitiveness of the institutions operating in the European markets.

Our goal will focus on the cost efficiency of these institutions in order to examine, for a seven years period, its evolution and the projected impact of the ECB Target2 - securities program and CSDR regulatory system. In this study, we will estimate the *translog* cost function using the OLS measure with the program *Stata*®. We will divide our estimation in six models. The first five consider the sample data of 2010-2016 and the last one considers the period of 2014-2016.

After this estimation, we will check if these institutions can achieve economies of scale, or not, and if they gain, or not, financial advantages for producing their levels of output.

Our work will be distributed in five chapters. The first will be the literature review, where we explore the most recent research and the motivation for our ideas. Chapter two presents the data collected, our model and the current methodology applied to it. The results will be discussed in Chapter three. We make our conclusions in Chapter four and limitations to our study plus further research, in Chapter five.

1. Literature Review

We examined some topics about clearing, settlement and custody, for post-trade processes of services that are made following to the execution of a trade. These services are provided mostly by financial market infrastructures such as Central Counterparties (CCPs), Central Securities Depositories (CSDs) and Custodians (e.g. Large Financial Institutions). However, few studies are available on the cost efficiency of settlement and custody institutions, namely CSDs and ICSDs (International Central Securities Depositories).

Important studies on these three key topics on the post-trade transactions gave us the idea to this study. If we see Milne (2007), he mentions that there are few theoretical models and empirical studies, and more research is needed to elaborate. So, there is a need for more insights and understanding of this major industry. On this insight, he identified two important empirical papers - Schmiedel *et al.* (2006) and Van Cayseel and Wuyts (2007) - which search for economies of scale and/or economies of scope in the clearing and settlement industry in the U.S.A, Asia-Pacific regions and/or Europe.

For Schmiedel et al (2006) the results were conclusive, it was proven the existence of substantial economies of scale related to both depository and settlement activities. It´s found that the US system is the most cost-efficient settlement system and the European and Asia-Pacific show potential unit cost savings. Furthermore, the results supported the idea that smaller institutions needed mergers/ integrations with other institutions in order to expand their depository and settlement business. In the end, its concluded that the best model in cost efficiency is the US one, leaving the EU industry with questions for the best of way to remove cost inefficiencies in clearing and settlement infrastructures.

For the case of Van Cayseel and Wuyts (2007), initially they agreed that by comparing to the US settlement and depository industry, the European industry is still very expensive, especially for cross-border settlement. Nonetheless, they also achieve the results intended by estimating their model. They reached the conclusion that smaller institutions can realize many economies of scale and larger institutions have still potential to reduce costs. Additionally, they also found economies of scope exiting in these institutions, they have reached the outcome if settlement is separated from issuance service and after held in different entities will encompass efficiency losses and cost increases. We curiously investigated has well previous works on the same subject done by the same authors or just by Van Cayseel himself. For Van Cayseel (2004) its focus in theoretical research in the competition and organization of the clearing and settlement industry. This paper debates more precisely some of the arguments from the C&S[1] industry, mostly advantages and disadvantages these institutions. In Van Cayseel and Wuyts (2006)[2], its investigated has well if economies of scale are present in European settlement and clearing organizations. However, comparing Van Cayseel and Wuyts (2007) work, the choice of variables (the same as in Schmiedel et al (2006)) and estimation techniques made are slightly different. Even so, they accomplished to find economies of scale in this industry. They conclude that European C&S industry is still very expensive, especially for cross-border settlements, which are proving to be inefficient because of lack of common technical standards, the presence of different business practices and an irregular fiscal, legal and regulatory framework.

The both main papers analyzed it´s cited two reports that identified the main difficulties to efficient cross-border clearing and settlement, in Europe - the Giovanni Group reports from 2002 and 2003. On these reports, it´s discussed the cross-border clearing and settlement arrangements in the European Union and the barriers that existed, on that time, for those arrangements. Later, in 2008, a group called "The European

[1] C&S stands for Clearing and Settlement.
[2] This paper is the one who might have led to the paper publish in the Journal of Banking & Finance in 2007.

Commission Clearing and Settlement Advisory and Monitoring Expert Group" (CESAME) issued a report built on four years of work, to help the European Union to remove the barriers to cross-border post-trading transactions. They have achieved some solutions for existing barriers, but the process of dismantling them, was still far from ending.

Another paper about settlement and clearing industry is from Li and Marinc (2015) focusing not only on cost efficiency, but on competition in the clearing and settlement industry. They used the Panzar–Rosse model to estimate the competitive indicator H-statistic, which shows whether clearing and settlement institutions operate under a monopoly, monopolistic competition, or perfect competition. They also compute the Lerner index of monopoly power of the institutions and the Boone indicator to measure competition.

In our analysis, like in all the empirical papers already mentioned, *translog* cost function is adopted in order to find out if settlement and custody institutions operate in a resourceful way. Therefore, we estimate the cost function to examine if there are, currently, economies of scale still present on CDSs institutions, based on Daglish *et al.* (2015). They use the Ordinary Least Squares (OLS), the Maximum Likelihood Estimation (MLE), the Seemingly Unrelated Regression (SUR) and the Shephard's Lemma, that can also be used to derive the cost-share equations for each input.

Regarding the economies of scale definition, it is known that it refers to the situation in which the cost of producing an additional unit of output (the marginal cost) of any product, decreases as the volume of the output increases. Other definitions considered on this analysis, can be found in the papers mentioned above.

The "Draft working document of post trading" by the European Commission (2003) and Loader (2014) helps define settlement, essentially as the transfer of securities from a seller to the buyer, and clearing as a process (via an organization that acts as an intermediary) of reconciliation of the sales and purchases of securities and, to be more direct, the process of entrusting the respective obligations of the buyer and seller in a security transaction. These two processes are made efficiently via four types of organizations: domestic central securities depositories (CSDs), international central securities (ICSDs), custodians and central counterparty clearing houses (CCPs). A CSD is a financial organization designed for the holding and settlement of domestic securities, such as shares, and an ICSD is a CSD that holds and settles international tradable securities from various domestic markets, being most of them Eurobonds. There are two ICSDs located within the EU, namely the *Clearstream Banking*, in Luxembourg, and *Euroclear Bank*, in Belgium.

Custodian is a financial institution that hold and safekeeps client's securities in order to minimize the risk of their theft or loss. These institutions can hold securities in electronic or physical form. A central counterparty clearing house (CCP) is an institution that acts as the "middle-man", directly or indirectly, between the operations of counterparties, so that they can assume their rights and obligations. They act as the counterparty to every transaction/trade from buyer to seller and seller to buyer[3].

In short, the settlement of securities, involves the clearing house, the local and international central securities depositories and the settlement agents of various participants (Loader (2014)).

Regarding cross-border securities settlements, we found additional concepts in a report for the same topic made by the Committee on Payment and Settlement Systems of the central banks of the Group of Ten countries (1995) and in discussion paper "Cross-Border Securities Clearing and Settlement Infrastructure in the European Union as a

[3] Information taken from Draft working document on post-trading by European Commission.

Prerequisite to Financial Markets Integration: Challenges and Perspectives" from de Carvalho (2004). For the last one, is mention that cross- border trading is, as it name suggest, a trade between counterparties (buyer and seller) from different countries, and it´s settlement only occurs when a securities settlement is made in distinctive countries of both counterparties.

The most interesting to fact on these last documents is the risk that exist for securities settlements. There is identified first the principal risk, that happens when one of counterparties fails to deliver the securities which were already paid, or in the opposite case, falling to deliver the payment when the security already received. One more risk is the replacement cost risk, that is linked to the risk of an unrealized transaction because of default of the counterpart before settlement is made. A third risk is the liquidity risk, that occurs when a counterparty doesn't settle an obligation when due, and only after certain time. Operational risk, that is due when series of events might happen delaying settlement. This event could be made by system issues, disparity of communications or even destroyed records. A final risk is the systemic risk, that arises when one institution fails to deliver to another institution, and because of that this institution is also failing its obligation to redeliver to another counterparty. For risk concerning only cross-border transactions there is mention of the Custody risk, related to the loss of a security held in custody due, for instance, to insolvency, operations problems. Second is legal risk, linked to legal uncertainty in the conclusion of the cross-border transaction. Third is the foreign risk that occurs from movements in the exchange rates between the trade and settlement date. This report specified that exist measures to avoid risk in cross-border securities settlement related to automation of the system, and clear legal provisions. One of them is the straight through processing (STP) automation. So basically, once a transaction is electronically entered its information is delivered to all main participants without any manual intervention. But this is not the only measure we discovered.

Regarding the costs in the European securities settlement structure, we found a report from Lannoo and Levin (2001). In these report mentions notions that we already discussed, like the connection between ICSDs and global custodians. The authors state that they are competitive but also complementary for each other, this is because ICSDs get their business from global custodians who wants to settled bonds through them and at the same time local custodians help ICSDs to perform safety associations with local CSDs.

But the main issues discussed are the problems with cross-border settlement that arise, according to Lannoo and Levin, from the fact that if the trade must be processed externally it needs an increase in the use of intermediaries and the creation of a back-office infrastructure, which creates higher transactions costs. Moreover, while speaking of costs, Lannoo and Levin have a chapter that addresses the costs elements in securities settlement that each market participant face. The first is infrastructure cots, mostly related with the fees charged for users of settlement systems. Indirect costs to users, that are constituted by back-office costs, banking and financial costs, cross-collateralization opportunity cost, failed transaction penalties and pipeline liquidity costs. Lastly, the costs of using intermediaries, investors have more costs when usually settle with foreign CSD, or via a most common intermediary such as ICSDs or global custodians.

There are two points of interest that lead to this analysis when comparing to all papers discussed so far. The first was the launch, in 2008, of the T2S project (TARGET2 - Securities) by the ECB. This project is a European securities settlement IT platform with the purpose of integration (offers delivery-versus-payment (DVP)[4] settlement across all

[4] DVP transactions are when the both securities and cash payment for them are exchange.

European securities markets) and bringing together the vastly fragmented securities settlement infrastructures in Europe. T2S aims to reduce the costs of cross-border securities settlement and to incentive competition and options between providers of post-trading services around Europe. T2S migration plan includes five periods[5] or waves. The first started on the 22nd of June 2015 and the final wave happened on the 18th of September 2017. Concerning this fact, and although the data collected and analyzed is from post crisis years, the full effects of the T2S project migration plans most likely won't be shown on our data.

The second point of interest is the creation of the CSD Regulation (CSDR)[6] by the European Parliament and European Council in 23rd of July 2014. The purpose was the improvement of securities settlement in the European Union and on central securities depositories. The objective is the improvement of efficiency and competitiveness of European Union financial markets, by creating a jointly regulatory framework for CSDs. This is also a recent project, but it plays a significant role on improving cost efficiency for cross border transactions around Europe.

Nevertheless, it seems that it is still a struggle to reduce the cost of cross-border securities settlement and increase competition for post-trading services in Europe. So, this study aims to examine the cost efficiency of the European Central Securities Depositories. The objective is to disentangle the post crisis effects on these institutions and the improvement impact of recent strategies.

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[5] For more information about T2S available: https://www.ecb.europa.eu/paym/t2s/html/index.en.html

[6] For more information on the Regulation available at: https://ec.europa.eu/info/business-economy-euro/banking-and-finance/financial-markets/post-trade-services/central-securities-depositories-csds_en.

2. Data and Methodology

2.1. Data

Data collected for this research was mostly taken from annual reports of respective settlement and clearing institutions (84 reports in total). Other sources like Amadeus and the webpages of the European Central Securities Depositories Association (ECSDA), each institution, the World Bank and the ECB, were also used to complete our data set. The research sample focused on European clearing and settlement institutions, therefore excluding U.S.A institutions.

Regarding the financial data, it was collected mostly from the financial statements of each institution for the period ranging from 2010 to 2016 - after the 2008 crisis[7]. The settlement and custody activity data was taken from the ECSDA webpage. To be able to compare the values of companies with different currencies, we applied the exchange rate at the end of each year[8], to convert those values to Euros.

The settlement and clearing institutions were selected based on their characteristics and size, even though some are quite similar. If we take aside the two ICSD mentioned, *Clearstream* and *Euroclear* (or three if we count *Six Sis* as an ICSD), we will see some smaller institutions with the same values of output.

There were some limitations on our research due to mergers of institutions (via horizontal integration, which is an association of institutions that used the same levels of products and via vertical integration, which one institution takes complete control over another that has different levels of products) that formed bigger groups and other circumstances where we were not able to collect information, namely *Iberclear* and

[7] The choice of the period of data selected is to see a most recent analysis on the cost efficiency of settlement instructions post the crisis.

[8] Annual Historical Exchange rates available at: https://www.ofx.com/en-au/forex-news/historical-exchange-rates/.

Monte Titoli, from Spanish and Italian CSDs markets, respectively. Hence, as shown in Table 1, we chose 12 institutions in total to proceed with this study, excluding others based on what was mention before. These compares with the 16, in Schmiedel *et al.* (2006), 10 in Van Cayseel and Wuyts (2007), and 46 in Li and Marinc (2015).

Table 1- CSDs Sample

Central Securities Depository Institutions	Acronym	Country	Type
Centrálny depozitár cenných papierov SR, a.s.	CDCP SR	Slovak Republic	CSD
Central Depository AD	CDAD	Bulgary	CSD
Clearstream Bank S.A (Deutsche Bôrse)	CBL	Europe	ICSD
Euroclear Bank	EOC	Europe	ICSD
Krajowy Depozyt Papierów Wartosciowych S.A.	KDPW	Poland	CSD
Sociedade Gestora de Sistemas de Liquidação e de Sistemas Centralizados de Valores	Interbolsa	Portugal	CSD
KELER Central Depository Ltd.	KELER	Hungary	CSD
Verdipapirsentralen ASA	VPS	Norway	CSD
VP Secutities SA	VP	Denmark	CSD
SIX SIS AG	SIX SIS	Switzerland	CSD/ICSD
Central Registry of Securities JSC Banja Luka	CR HoVRS	Bosnia and Herzegovina	CSD
Depozitarul Central SA	DC	Romania	CSD

2.2. Methodology

As mentioned before, the main objective of this study is to conclude about the existence of economies of scale on the settlement and clearing industries, and if the existing institutions operate in an efficient way. To achieve this, we must assess the activity costs of the institutions in our sample, and define proxies in order to obtain their respective inputs and outputs. In this respect, our research is based on two previous papers - Schmiedel *et al.* (2006) and Van Cayseel and Wuyts (2007). On both papers, the *translog* cost function is estimated and the existence of economies of scale is found.

The methodology implemented is under a multi-product atmosphere, where it is assumed that each settlement institution is a known multi-product firm because, comparing to other firms that produces only one level of output, these institutions produces different levels of outputs. These types of firms need to allocate correctly their inputs to produce more than one output. In line with this, to calculate the cost function we included some identical variables, namely the operating expenses (including depreciation) to serve as a proxy of the total costs made by each settlement and clearing institution, labeled *Tc*. The variable is used to get closer to the cost made by each institution.

For the input and output cost variables, we used concrete data from each institution because the information for all the CSD selected were disperse and presented in a different form from one to another. Also based on the two papers mentioned above, for first output measurement we thought it would be appropriate to derive the investor side with the total number of participants in each CSD. Participants are defined in the FMA[9] as "a person that holds in custody and administers securities or an interest in securities and that has been accepted by a central securities depository as a participant in that central securities depository". They can be classified as non-domestic participants and domestic participants. In sum, we use this variable to quantify for instance, the financial institutions, brokers or dealers trading in securities, insurance companies and even banks that process transactions through the CSD and ICSD. Therefore, we will name this variable *Part.*

The second output variable aims to reflect the revenues of the depository services, meaning, the services of custody of the securities as well the legal ownership them. This variable is the same as used by Schmiedel *et al.* (2006). Hence, we chose the value of

[9] The Financial Markets Authority (FMA) plays a critical role in regulating capital markets and financial services in New Zealand.

securities held on CSDs accounts to proxy the revenues amounts that each institution has. We labeled this variable as *Vheld*.

As for the input variables, it is known in economic studies that in order to assess the total cost, one can include the price of labor as a variable cost plus the fixed cost. We chose to follow the same approach of Van Cayseele and Wuyts (2007) and used as inputs to the price variable, the labor costs and other costs, denominating them *Lc* and *Oc*, respectively. The labor cost was calculated previously by dividing employee costs (e.g. wages and social security) by the number of total employees that each CSDs has. As for the other costs, these are difficult to find and to determine in the annual report of each institution. As we need another price variable to include from our multi product institution, therefore we decided to follow the same path as Van Cayseele and Wuyts (2007). Hence, we considered the GDP per capita [10] of 2008 [11] per country of the corresponding CSD as the based value and, we divided each year GDP, from 2010 to 2016, for its base number. For example, to determine the others cost for the Portuguese CSD (Interbolsa) in 2016, the calculation is the Portuguese GDP in 2016 divided by the based value. So, in sum, the other cost from each institution from each country will be from each GDP ratio.

It's important to refer that all values are in thousands of euros, except for those of number of participants.

[10] The GDP per capita data was obtained from World Bank national accounts data available at: https://data.worldbank.org/indicator/NY.GDP.PCAP.CD

[11] We chose 2008 as a base year to give a wider range than the seven years present on our data

2.3. Description of the Model

The cost function applied in this analysis follows the one present in Van Cayseel and Wuyts (2007). However, we selected different variables. The *translog* cost function is formed by applying the natural logarithm (ln) to all variables.

Therefore, the general form of the model is:

log_Tc = f (*log_Part*, *log_Vheld; log_Lc*, *log_Oc*)

The dependent variable is represented by the total operating costs (including depreciation) and the independent variables are the outputs (*log_Part* and *log_Vheld*) and the two inputs *log_Lc* and *log_Oc*. In addition, we use a dummy variable to differentiate ICSDs from CSDs.

The full Pooled OLS *translog* cost function that we will estimate is then the following:

$$
\begin{aligned}
\log(Tc) = c \, + \, \alpha_1 \log(Part) + \alpha_2 \log(Vheld) + \left(\frac{1}{2}\right) \beta_{11}[\log(Part)]^2 \\
+ \left(\frac{1}{2}\right) \beta_{22}[\log(Vheld)]^2 + \beta_{12} \, \log(Part) \log(Vheld) + \, \gamma_1 \log(Lc) \\
+ \gamma_2 \log(Oc) + \left(\frac{1}{2}\right) \delta_{11}[\log(Lc)]^2 + \left(\frac{1}{2}\right) \delta_{22}[\log(Oc)]^2 \\
+ \, \delta_{12} \, \log(\mathrm{Lc}) \log(\mathrm{Oc}) + \, \lambda_{11} \, \log(Part) \log(Lc) \\
+ \, \lambda_{12} \, \log(Part) \log(Oc) + \, \lambda_{21} \, \log(Vheld) \log(Lc) \\
+ \lambda_{22} \, \log(Vheld) \log(Oc) + \, \rho_1 ICSD + \epsilon
\end{aligned}
$$

Note: We created variable name *_half* that stats for $\left(\frac{1}{2}\right)$

After this estimation, Van Cayseel and Wuyts (2007) applied two shares equations using the Shephard's Lemma. More precisely they derivate the *Translog* cost function in order of each input. They added these equations to the main *translog* function so that they could use the Seemingly Unrelated Regressions (SUR) from Zellner (1962). This is a general linear regression model that contains several regression equations, each having its own dependent variable. We concluded that its specific characteristics of this approach were not in our scope and decided not to apply in our analysis.

Thus, our assessment will be focused on estimating a pooled OLS for the period considered, as well as for the sub period 2014 to 2016. This shorter period was chosen because there are ongoing attempts, previous mentioned, to reduce the costs and increase competition in cross-border settlement industry.

We will analyze 5 models, step by step, and a final model that considers the shorter period. We will then compare the results, based on the level of significance of the coefficients and the R^2 to prove that our model fits.

For elasticity of scale, we will use a similar approach as the paper of Van Cayseel and Wuyts (2007). So, we follow the same path as we agree on the understanding that we will achieve economies of scale if the sum of the both output elasticities is smaller than 1. Otherwise there will be diseconomies of scale if the sum will be higher than 1. We will also take the first derivative of each input in relation to the total costs so that we can achieve the respective elasticity equations for each output. Subsequently, we need to identify the total elasticity corresponding to both output measures so that we can reach our final conclusions. This total elasticity proves if there exist scales economies (SE) or not.

The following expressions were attained from the derivation of the *translog* cost function. We used the coefficients of the inputs and outputs from the previous OLS estimation of this function so that we can reflect the correct function derivation and coefficient values.

The elasticities functions regarding each output we will be described below:

$$\varepsilon_{Part} = \frac{\partial log(Tc)}{\partial log(Part)} <=>$$

$$\varepsilon_{Part} = \alpha_1 + \beta_{11}\log(Part) + \beta_{12}\log(Vheld) + \lambda_{11}\log(Lc) + \lambda_{12}\log(Oc)$$

$$\varepsilon_{Part} = \frac{\partial log(Tc)}{\partial log(Vheld)} <=>$$

$$\varepsilon_{Vheld} = \alpha_2 + \beta_{22}\log(Vheld) + \beta_{12}\log(Part) + \lambda_{21}\log(Lc) + \lambda_{22}\log(Oc)$$

SE will be represented by the total value of elasticities presented on our multi-product estimations:

$$SE = \varepsilon_{Part}(Part, Vheld) + \varepsilon_{Vheld}(Part, Vheld)$$

3. Results

3.1. Descriptive Statistics

The program used was *Stata*®. In total, we have 12 institutions, 10 from specific European countries and 2 ICSD for international and European environment.

Figure 1 in the appendix, provides the descriptive statistics showing that there is notable dispersion of the variables. Some outliers might exist and could affect our data. Skewness is positive, and kurtosis is higher than 3, meaning that the dataset has heavier tails than a normal distribution. Figure 2 gives average cost per unit of output to put in evidence the cost efficiency of these intuitions. Figure 3 and 4 show scatter plots taken from the Stata program representing the correlations between the average cost per participant of a settlement institution and the average cost per value of securities held in the accounts. We computed these scatter plots after finding the average costs per level of output, presented in Figure 2. As shown in the first scatter plot, the average cost per value of securities held decreases quickly at the first levels/values of securities held and then maintains a more or less constant average cost. Regarding the second scatter plot for the average cost per participant, we observe again a quick decrease in average cost but, shortly after, with the increase in the number of participants, the average cost maintains a more or less constant value above 200. Nevertheless, it's clear the gap between the CSDs, with less participants, and the ICSDs with higher numbers of participants.

3.2. Econometric Approach

For our econometric approach, the type of data we could use are a panel data set or cross-sectional data. We tested both and each of these data gave the same results. So, we firstly have associated the name of each CSD to a general number and constructed the panel data yearly from 2010 to 2016. Basically, the panel variable is *CSDnumb* (strongly balanced) and our time variable is *Years*, 2010 to 2016. In the end we followed the simple path an only used a simple series of regressions using the cross-sectional data.

We computed 4 basic models step by step after transforming all variables in logarithmical formats on a total of 84 observations, in order to estimate the full *translog* function. For model 1 (shown on table 6) we have estimated both outputs *Vheld* and *Part*, plus the dummy variable created to differentiate ICSD which has more than 1000 Participants. This binary variable will take a value of 1 if this happens otherwise it´s will be 0. For Model 2 (table 7) we will add the interaction term[12] of both output independent variables. For the Models 3 and 4 we will add the inputs variables (*log_Oc* and *log_Lc*) and their respective interaction term, as shown in table 8 and 9 in the appendix.

The conclusion of these 4 basic models is that with the addition of more variables, the coefficients become more significant and the R^2 closer to 1.

As for the full estimation of the *translog* function (Table 10), the results are quite reasonable. There are at least 12 coefficients that are statistical significant at a 1% level and an R-squared = 0.9891 and Adj. R-sq. of 0.9867 and the *log_Lc* coefficient is significant at 5% level. The dummy variable with a positive coefficient, is not statistical significant, although we decided to keep it in our sample. We can compare the R-squared results from other estimations made comparing the Adj. R-squared around 0.9471, in

[12] Interaction effects occur when the effect of one variable depends on the value of another variable

Schmiedel et al. (2006), R-squared of 0.8319 in Van Cayseel and Wuyts (2007), and Adj. R-squared around 0.962 in Li and Marinc (2015).

For the sub period chosen, our sample has 36 observations and the results are presented in Figure 5 and Table 11, in the appendix. The results show a poor significant improvement. Nevertheless, the descriptive statistics have some changes and the model 6 shows lower insignificant coefficients than before. There are now 4 coefficients statistical significant at 1% level, 4 at 5% level and 2 at 10% level. The dummy variable is still insignificant but now negative.

As mention before, the scale elasticities results were attained by taking the first derivative of the translog cost function in respect of each output variable, but we also dividing then by the sample mean and median. So, in each elasticity equitation we discovered its mean and median values.

Therefore, to proxy the difference between smaller institution with less value of securities held and the bigger ones with higher amounts, we sorted the observations of our data into ascending order based on the values of the variable *log_Vheld* and then split it by 4 quantiles. Now each set of values of the variable divide a frequency distribution equal to 4 groups. Tables 2 and 3 show the scales elasticities in total for both outputs for the period 2010-2016 by the 4 quantiles previous defined. We named *ElastPart* and *ElastVheld* for both elasticities of each output.

Quantile/Median	ElastPart	ElastVheld	SE
1	-1.431	1.732	0.301
2	-0.416	1.071	0.654
3	1,013	-0.288	0.725
4	1.06	-0.137	0.929

Table 2 -Elasticity by Sample Median

Quantile/Mean	ElastPart	ElastVheld	SE
1	-0.94	1.14	0.2
2	-0.496	1.007	0.511
3	0.949	-0.082	0.867
4	0.985	-0.089	0.896

Table 3 -Elasticity by Sample Mean

The results show a different measure for the total elasticities (scale economies). In overall its shown that the sum of scale elasticities is higher for the larger institutions, but even for them, costs savings can be obtained. This means, that larger CSD can exploit economies of scale but with slighter extent than the smaller ones. For example, the 4th quantile, from the mean results, corresponds to larger CSD with higher values of Vheld and it displays a value for scale economies of 0.896, this value if clearing less the 1 , so it proves the fact these institutions can achieve the outcome desired. Consequently, we will have better opportunities to achieve larger economies of scale for smaller institutions, that corresponds to the quantiles 1. These institutions can exploit with greater extent these economies and can still improve by the means of vertical/ horizontal integration, like discussed in Schmiedel et al (2006) and Van Cayseel and Wuyts (2007).

For our subsample for the period of 2014-2016 our results are the following for the sample mean and sample median. (Tables 4 and 5):

Quantile/Mean	ElastPart	ElastVheld	SE
1	-0.944	1.14	0.146
2	-0.496	1.007	0.511
3	0.949	-0.082	0.867
4	0.98	-0.089	0.89

Table 4- Elasticity by sample Mean for 2014-2016

Quantile/Median	ElastPart	ElastVheld	SE
1	-1.43	1,73	0.3
2	-0.41	1.07	0.66
3	1.01	-0.28	0.73
4	1.06	-0.138	0.922

Table 5 -Elasticity for sample Median for 2014-2016

Comparing to the longer period, the results didn't change much. We continue to have a distinction for smaller institutions with greater and higher chances to achieve economies of scale. So, we conclude that these institutions, from 2014 to 2016, can continue to yield advantage of these economies.

4. Conclusions

Considering the results obtained and the incentive created by the ECB and other regulatory entities, it seems that clearing and settlements institutions can still take advantage of economies of scale. We expect that these centralized regulations and the T2S platform will contribute to improve competitiveness and cost efficiency around Europe for these institutions, as the objectives of the CSD Regulation are consistent with the Target2 Securities (T2S) program. The two initiatives are complementary, with the regulation harmonizing legal aspects of the securities settlement and the rules for CSDs at European level, allowing the T2S, which harmonizes the operational aspects of securities settlement, to attain its goals more effectively.

But the main challenge is to face the differences for the cost efficiency of CSDs from other continents. Namely, the U.S.As CSDs (e.g. The Depository Trust & Clearing Corporation), on which according to most authors discussed like, Schmiedel *et al.* (2006) and Li and Marinc (2015), have more cost efficiency advantage than European CSDs.

To sum up, our objective was achieved and by estimating their total costs, we did manage to prove that these institutions, can still take advantage of economies of scale.

5. Limitations and Further Research

Our data has the limitation of not being according to one standard of financial reporting because different institutions follow either IFRS or National GAAP, and each reporting standards encompasses different rules. This means that data collect from Amadeus or other annuals reports could be not be linear with each other. Also, the transformation of currency using the annual rates could lead to misleading values, but we did our best to achieve to most reasonable results possible.

Future work, further analysis could be done regarding the multicollinearity and/or heterogeneity environment problems within the CSDs. It is thinkable the use of alternative input and/or output variables and different type of regressions, like Van Cayseel and Wuyts (2006). But the main work could be to include the Central Counterparty Clearing House (CCP), which, as mentioned before, offers financial services for clearing trades, and Custody Banks, which offers safekeeping of securities like normal CSDs do. These institutions could be a good sum up to the cost efficiency analysis. The most effective idea could be to link the three parts from clearing, settlement and custody together and to see which of them are more cost efficient. We leave this thought for further consideration.

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Appendix

stats	TC	Part	Vheld	Lc	Oc
mean	88651.19	325.2976	1.81e+09	63.46005	1.726693
p50	17615.74	86.5	4.06e+08	61.701	1.052064
skewness	1.711479	1.699744	2.164331	.1869614	2.97139
sd	150361.5	505.5501	3.27e+09	43.63761	2.422612
max	503300	1617	1.26e+10	144.9996	10.66492
min	761.3089	10	6313000	.8666621	.1271508
kurtosis	4.216964	4.13527	6.561761	1.629353	10.14191

Figure 1- Descriptive statistics

stats	AvPart	AvVheld
mean	239.4491	.000085
p50	224.2333	.0000648
skewness	1.072183	1.145722
sd	181.5005	.0000639
max	915.9901	.0003055
min	7.344345	.0000105
kurtosis	4.612193	4.080808

Figure 2 - Averages Costs per Output

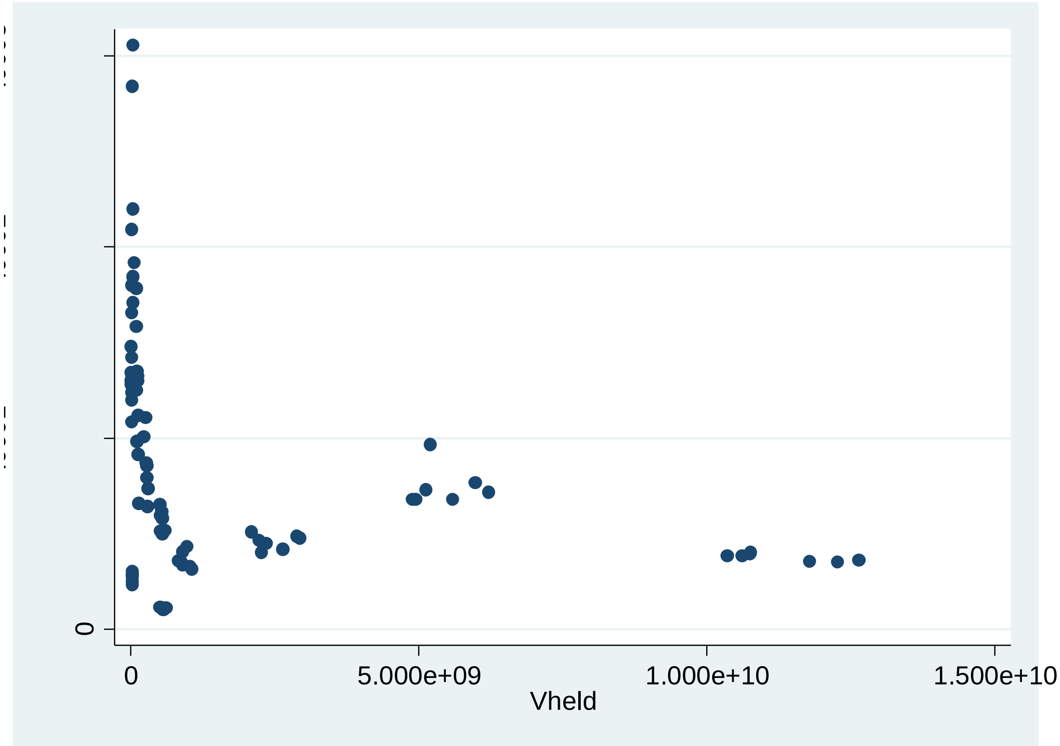

Figure 3- Average Cost per Value of Securities Held

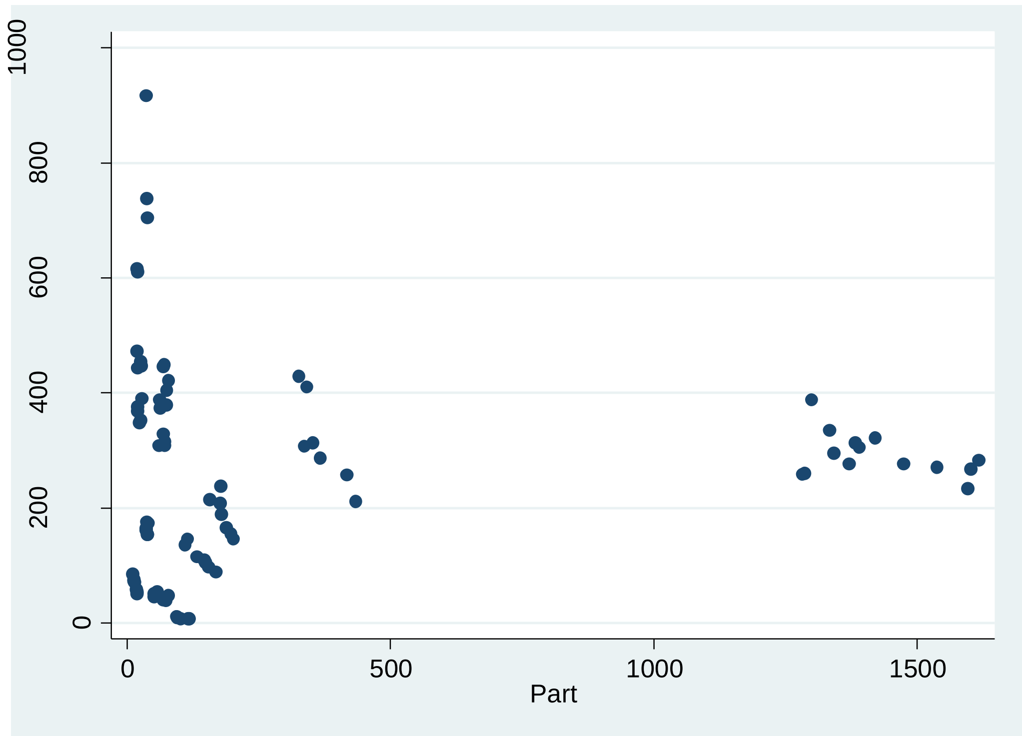

Figure 4 -Average Cost per Participant

Table 6-Model 1

```
. regress log_Tc log_Part log_Vheld ICSD
```

Source	SS	df	MS
Model	287.04649	3	95.6821635
Residual	39.0193025	80	.487741282
Total	326.065793	83	3.92850353

Number of obs =	84
F(3, 80) =	196.17
Prob > F =	0.0000
R-squared =	0.8803
Adj R-squared =	0.8758
Root MSE =	.69838

log_Tc	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
log_Part	.08947	.1147426	0.78	0.438	-.1388749	.317815
log_Vheld	.6931648	.0601181	11.53	0.000	.573526	.8128037
ICSD	.7401705	.3359933	2.20	0.030	.0715226	1.408818
_cons	-4.25294	.901934	-4.72	0.000	-6.047846	-2.458034

Table 7-Model 2

```
. reg log_Tc c.log_Part##c.log_Vheld ICSD
```

Source	SS	df	MS
Model	289.445926	4	72.3614814
Residual	36.6198674	79	.463542625
Total	326.065793	83	3.92850353

Number of obs =	84
F(4, 79) =	156.11
Prob > F =	0.0000
R-squared =	0.8877
Adj R-squared =	0.8820
Root MSE =	.68084

log_Tc	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
log_Part	-1.586095	.7449108	-2.13	0.036	-3.068803	-.1033872
log_Vheld	.3188904	.1746338	1.83	0.072	-.0287094	.6664902
c.log_Part#c.log_Vheld	.0886785	.038977	2.28	0.026	.0110967	.1662604
ICSD	-.2097169	.5306615	-0.40	0.694	-1.265972	.8465383
_cons	2.721192	3.188968	0.85	0.396	-3.626289	9.068673

Table 8 - Model 3

```
. reg log_Tc log_Vheld log_Part c.log_Vheld#c.log_Part log_Oc log_Lc c.log_Oc#c.log_Lc ICSD

      Source |       SS       df       MS              Number of obs =      84
-------------+------------------------------           F(  7,    76) =  106.88
       Model |  295.997029     7  42.2852898           Prob > F      =  0.0000
    Residual |  30.0687643    76  .395641635           R-squared     =  0.9078
-------------+------------------------------           Adj R-squared =  0.8993
       Total |  326.065793    83  3.92850353           Root MSE      =    .629

------------------------------------------------------------------------------------------
                   log_Tc |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
--------------------------+---------------------------------------------------------------
                log_Vheld |    .135935   .1701898     0.80   0.427    -.2030273    .4748973
                 log_Part |  -2.521383   .7306302    -3.45   0.001    -3.976559   -1.066206
                          |
c.log_Vheld#c.log_Part    |    .139523   .0381869     3.65   0.000     .0634671    .2155789
                          |
                   log_Oc |  -1.548337   .4633172    -3.34   0.001    -2.471114    -.625561
                   log_Lc |  -.2020336   .0653222    -3.09   0.003    -.3321341   -.0719332
                          |
         c.log_Oc#c.log_Lc|   .3938571   .1117496     3.52   0.001     .1712884    .6164257
                          |
                     ICSD |  -.6448255   .5027844    -1.28   0.204    -1.646207    .3565565
                    _cons |   6.607113   3.115179     2.12   0.037     .4026964    12.81153
------------------------------------------------------------------------------------------
```

Table 9 - Model 4

```
.
. reg log_Tc c.log_Vheld##c.log_Part log_Oc log_Lc ICSD

      Source |       SS       df       MS              Number of obs =      84
-------------+------------------------------           F(  6,    77) =  106.78
       Model |  291.082441     6  48.5137401           Prob > F      =  0.0000
    Residual |  34.9833525    77  .454329253           R-squared     =  0.8927
-------------+------------------------------           Adj R-squared =  0.8844
       Total |  326.065793    83  3.92850353           Root MSE      =  .67404

------------------------------------------------------------------------------------------
                   log_Tc |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
--------------------------+---------------------------------------------------------------
                log_Vheld |   .2935856   .1759642     1.67   0.099     -.056804    .6439752
                 log_Part |  -1.737679   .7458056    -2.33   0.022    -3.222767   -.2525901
                          |
c.log_Vheld#c.log_Part    |   .0983211   .0389566     2.52   0.014     .0207486    .1758936
                          |
                   log_Oc |   .0498834   .1018419     0.49   0.626    -.1529097    .2526765
                   log_Lc |  -.1246834   .0659305    -1.89   0.062    -.2559678     .006601
                     ICSD |   -.342834   .5309042    -0.65   0.520    -1.399999    .7143313
                    _cons |   3.494487   3.201279     1.09   0.278    -2.880073    9.869048
------------------------------------------------------------------------------------------
```

Table 10- Model 5 - Full OLS estimation of the Translog Function

Source	SS	df	MS
Model	322.518333	15	21.5012222
Residual	3.54746006	68	.05216853
Total	326.065793	83	3.92850353

Number of obs	= 84
F(15, 68)	= 412.15
Prob > F	= 0.0000
R-squared	= 0.9891
Adj R-squared	= 0.9867
Root MSE	= .2284

log_Tc	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
log_Oc	-18.18961	2.450051	-7.42	0.000	-23.07861	-13.30061
log_Lc	4.11796	1.591231	2.59	0.012	.9427079	7.293213
c.log_Lc#c.log_Oc	.552883	.1671808	3.31	0.002	.2192788	.8864871
log_Vheld	11.18285	1.186611	9.42	0.000	8.815008	13.5507
log_Part	-12.63878	1.032575	-12.24	0.000	-14.69925	-10.57831
c.log_Vheld#c.log_Part	.8117032	.1013416	8.01	0.000	.6094792	1.013927
c.log_Vheld#c.log_Oc	1.063703	.1413734	7.52	0.000	.7815971	1.345809
c.log_Vheld#c.log_Lc	-.2728991	.102831	-2.65	0.010	-.4780952	-.067703
c.log_Part#c.log_Oc	-.8512295	.107907	-7.89	0.000	-1.066555	-.6359045
c.log_Part#c.log_Lc	.2671396	.1581614	1.69	0.096	-.0484666	.5827459
c.__half#c.log2_Part	-.8407729	.2069112	-4.06	0.000	-1.253658	-.427888
c.__half#c.log2_Vheld	-.6982068	.0992318	-7.04	0.000	-.8962207	-.5001929
c.__half#c.log2_Lc	.0118513	.1106275	0.11	0.915	-.2089024	.232605
c.__half#c.log2_Oc	-1.751853	.2670155	-6.56	0.000	-2.284674	-1.219032
ICSD	.7108369	.4539776	1.57	0.122	-.1950613	1.616735
_cons	-81.11691	7.345062	-11.04	0.000	-95.77375	-66.46006

stats	TC	Part	Vheld	Lc
mean	92748.48	328.1667	1.97e+09	63.9
p50	17213.42	78.5	4.04e+08	61.701
skewness	1.645299	1.715957	2.114768	.1557322
sd	157558.9	532.1336	3.57e+09	42.84694
max	457700	1617	1.26e+10	138.0412
min	831.4099	10	6313000	.8666621
kurtosis	3.937529	4.149028	6.288992	1.639018

Figure 5- Descriptive statistics for 2014-2016

Table 11- Model 6 from 2014-2016

Source	SS	df	MS
Model	143.85541	15	9.59036066
Residual	.759897868	20	.037994893
Total	144.615308	35	4.13186594

Number of obs	= 36
F(15, 20)	= 252.41
Prob > F	= 0.0000
R-squared	= 0.9947
Adj R-squared	= 0.9908
Root MSE	= .19492

log_Tc	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
log_Oc	-14.3149	4.822474	-2.97	0.008	-24.3744	-4.255393
log_Lc	9.611262	3.666409	2.62	0.016	1.963266	17.25926
c.log_Lc#c.log_Oc	-.02466	.2124731	-0.12	0.909	-.4678712	.4185512
log_Vheld	6.75357	2.784157	2.43	0.025	.9459207	12.56122
log_Part	-8.440246	2.502686	-3.37	0.003	-13.66076	-3.219733
c.log_Vheld#c.log_Part	.2603529	.231592	1.12	0.274	-.2227395	.7434454
c.log_Vheld#c.log_Oc	1.026388	.3481883	2.95	0.008	.3000797	1.752696
c.log_Vheld#c.log_Lc	-.705435	.2517831	-2.80	0.011	-1.230645	-.1802246
c.log_Part#c.log_Oc	-1.087108	.5482689	-1.98	0.061	-2.230777	.0565604
c.log_Part#c.log_Lc	1.003678	.4139255	2.42	0.025	.1402447	1.867111
c.__half#c.log2_Part	-.0186604	.3979125	-0.05	0.963	-.8486914	.8113707
c.__half#c.log2_Vheld	-.2505465	.235483	-1.06	0.300	-.7417555	.2406625
c.__half#c.log2_Lc	-.0417594	.2068027	-0.20	0.842	-.4731423	.3896236
c.__half#c.log2_Oc	-1.346832	.7141764	-1.89	0.074	-2.836578	.1429135
ICSD	-.5597101	1.076985	-0.52	0.609	-2.806261	1.68684
_cons	-59.95262	17.03713	-3.52	0.002	-95.49146	-24.41378