

**"The Welfare Effects of
Vertical Integration in the Securities Clearing
and Settlement Industry"**

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EXECUTIVE SUMMARY

The European Securities Clearing and Settlement Industry is currently experiencing a vast movement of consolidation. This is encouraged by the European Commission, who seeks to establish a single market for the issuance and trade of financial securities across the European Union, and in parallel reduce the cost of cross-border transactions. Several forms of integration have been taking place in recent years. Horizontal integration for example has taken the form of consolidations of exchanges, Central Counterparties (CCPs) or Central Securities Depositories (CSDs). Vertical integration has on the other hand taken the form of consolidations between an exchange, a CCP, and a CSD or alternatively a CSD also performing custodian bank activities, forming what is known as an ICSD (International Central Securities Depository). In a recent communication to the European Council and Parliament (Commission of the European Communities, 2004) the European Commission refuses to take any position about which form of consolidation is more likely to maximize social welfare. It goes as far as stating that "Market forces will determine the "final" structure of the Clearing and Settlement industry" (p. 11), implicitly taking for granted that the market outcome will coincide with the social optimum.

The objective of this article is to challenge this view by showing that market forces will not necessarily lead to a socially efficient industry structure. We offer a simple comparative welfare analysis of two industry structures, one with a unique CSD servicing competing custodian banks (the CSD model), the other with a ICSD competing with custodian banks (the ICSD model). This analysis shows that the choice of the industry structure may have important effects on social welfare. It may also have important redistributive consequences, i.e. on the repartition of economic surplus between different categories of final users.

Our formal model allows us to pinpoint the main trade-offs involved in the choice of the industry structure. Moving from the CSD model to the ICSD model has several consequences:

- It changes the nature of the settlement service, by substituting settlement in commercial bank money to settlement in Central Bank money.
- On the other hand it also reduces the marginal cost of transactions and the number of intermediaries involved in these transactions.
- Finally it reduces the intensity of competition for complementary banking services. By integrating with a custodian bank, a CSD can increase its

profit by either excluding competing banks or charging high access prices to these competing banks, which may in turn lead to the exclusion of some of the final investors. The impact on the prices paid by final investors would be to reduce: variable fees (due to the decrease in marginal costs) but increase fixed fees (associated to maintaining investors' accounts with the custodian bank). This would be favourable to broker and dealers but would typically penalize retail investors.

Such undesirable consequences can in principle be avoided by regulation. Indeed, requiring accounting and governance separation between the ICSD and its banking subsidiary, and providing access to depository and settlement services by other banks can restore the efficiency of competition for banking services.

However such a regulation may be faced with potential problems:

- The ICSD does not have any incentive to reveal the information about its costs that the regulator would need.
- In any case, it may be difficult for the regulator to separate the costs of settlement services from those of associated banking services.
- More importantly, the presence of indirect externalities with issuers ("two-sidedness") implies that cost-based pricing may not constitute an appropriate benchmark.

1- Introduction

The European Securities Clearing and Settlement Industry is currently experiencing a vast movement of consolidation. This is encouraged by the European Commission, who seeks to establish a single market for the issuance and trade of financial securities across the European Union, and in parallel reduce the cost of cross-border transactions. Several forms of integration have been taking place in recent years. Horizontal integration for example has taken the form of consolidations of exchanges, Central Counterparties (CCPs) or Central Securities Depositories (CSDs). Vertical integration has on the other hand taken the form of consolidations between an exchange, a CCP, and a CSD or alternatively a CSD also performing custodian bank activities, forming what is known as an ICSD (International Central Securities Depository).

In a recent communication to the European Council and Parliament (Commission of the European Communities, 2004) the European Commission refuses to take any position about which form of consolidation is more likely to maximize social welfare.¹ It goes as far as stating that "Market forces will determine the "final" structure of the Clearing and Settlement industry" (p. 11), implicitly taking as granted that the market outcome will coincide with the social optimum.

The objective of this article is to challenge this view by showing that market forces will not necessarily lead to a socially efficient industry structure. We offer a simple comparative welfare analysis of two industry structures, one with a unique CSD servicing competing custodian banks (the CSD model), the other with a ICSD competing with custodian banks (the ICSD model). This analysis shows that the choice of the industry structure may have important effects on total welfare, but also on the repartition of this welfare between different categories of final users. We also show that, in principle, regulation of access could be a way to avoid such undesirable consequences, and restore efficiency of competition for banking services. However such a regulation would, in practice, be confronted with potential difficulties.

The plan of the remainder of this article is as follows. Section 2 briefly reviews the academic literature on the clearing and settlement industries. Section 3 presents our formal model of competition between custodian banks. We then proceed by determining the competitive equilibrium of the banking industry, depend on the industry structure: separation between the CSD and custodian banks (Section 4) or vertical integration (Section 5), with and without regulation. In Section 6 we explore the reasons why regulation of an ICSD might be difficult to implement. Section 7 concludes.

¹ For example on p. 27 "the Commission is neutral on the question of vertical or horizontal consolidation...".

2- *A Review of the academic literature*

Let me start by reviewing two empirical papers, among the very few available on the subject. Schmeidel et al.(2004) investigates the existence and extent of economies of scale in depository and settlement systems. Their data set consists in the balance sheets and income statements of 16 settlement institutions (including the two ICSDs) in Europe, North America and Asia over the period 1993-2000. The authors estimate different regressions (loglinear or translog) of total operating costs of these institutions over two outputs variables (the number of settlement instructions and the value of securities deposited), one input price variable, proxied by per capita GDP, a time trend and an ICSD dummy. The results are not very conclusive, since the coefficients of the output variables are not significant. However, the authors conclude that economies of scale are present, but that they differ a lot by size and region of the settlement institutions (they are smaller for large institutions and in the US). The ICSD dummy is positive and significant and the time trend indicates improved cost effectiveness over the sample period.

Van Cayseele and Wuyts (2005) estimate a translog cost function for settlement and safekeeping services (custody). They find that economies of scale are quickly exhausted, while economies of scope are present. However, they don't have any ICSD in their data set, and they do not include the activities of custodian banks in their analysis. For these two reasons, they are not able to answer the fundamental question, namely is an ICSD more efficient (for providing jointly the services usually provided by CSDs and custodian banks) than the CSD and the custodian bank taken separately?

Among theoretical papers the most relevant to our analysis is Holthausen and Tapking (2004). This paper models competition between a CSD and a custodian bank for servicing small banks, which can either become members of the CSD or else use the custodian bank as an intermediary. The CSD and the custodian bank thus compete for offering conservation services, but the CSD is a monopoly on the settlement activity. The CSD sets two prices: one for opening a securities account (depository function), the other for trade settlement. The custodian bank reacts by setting its own prices for custody and settlement. A relatively complex model is constructed to generate network externalities and gains from netting trades between investors. However some investors also have needs for additional services only provided by the custodian bank. As a result of the interaction between network externalities and these exogenous preferences, the socially optimal allocations are such that a majority of the investors chooses one of the providers (i.e. they are not symmetric). But in the absence of regulation, the CSD is able to leverage its monopoly power on settlement for attracting a majority of investors. This is because the CSD is able to raise the cost of its competitor for providing services to final investors. However, due to network externalities, the proportion of final users who hold direct accounts with the CSD is not necessarily excessive, from a social welfare perspective. Hence there is no clear case for regulating CSDs.

A number of other papers are also interesting but less directly relevant to our analysis. For example two papers by Kauko (2002, 2003) study the strategic use of links between CSDs as a way to commit not to charge too high fees for secondary market services. This allows CSDs to increase their revenues from primary markets services. These papers, although quite complex, are very interesting because they are the only ones (to date) to model explicitly the two-sided nature of the industry, by taking into account the security issuers as well as the investors. They show in particular that platforms are likely to subsidize issuers and tax investors. Similarly, Tapking and Yang (2004) analyse different forms of industry structures in a two country model with exchanges and CSDs: complete separation (CS), vertical integration (VI) within each country, horizontal integration of the two CSDs, either at the purely “legal” level (LHI) or also at the technical level (THI). They show that this last system dominates all the other and that VI is better than CS. Due to the complementarity of the services provided by the exchanges and the CSDs, horizontal merger is in fact pro-competitive. Koppl and Monnet (2003) also analyse the impact of integration between CSDs an exchanges and arrive at very different conclusions. They show that vertical silos can prevent efficiency gains from horizontal consolidation. They claim that their results may explain the failure of the merger between DBorse and the LSE.

Finally let me mention three articles that do not contain any formal analysis but contribute to the debate about the industrial organisation of the security industry. Knieps (2004) tries to put forward the view that end custodians can be put in competition (he claims that “clearing and settlement are competitive services”) as long as the technical regulatory function (i.e. the notary function)- is provided in a non discriminatory fashion. Similarly Serifsoy and Weiss (2003) try to assess the pros and cons of different post market architectures and argue that contestable monopolies are the relevant paradigm. Van Cayseele (2004) discusses possible anti-trust concerns and opposes two radical views: a contestable quasi monopoly “view and a "regulated pan-European monopoly". He argues in favour of the first.

We now proceed to our formal analysis.

3- *Competition between Custodian Banks*

We consider a model in the spirit of the one developed by Holthausen and Tapking (2003). There is a unique CSD, two competing custodian banks labelled $i = 1, 2$, and a large number of investors. Following the definitions of the functions usually assigned to the different protagonists in the clearing and settlement industry (see for example Russo et al., 2001) we consider that the CSD provides depository and settlement services² while custodian

² See Russo et al. (2004), p. 12: "CSDs typically provide securities account maintenance, registration services, depository services and settlement services". However Milne (2004) argues that settlement services can be separated from depository services and provided competitively.

banks provide complementary banking services such as custody, accounts management and more importantly securities lending and provision of liquidity to the final investors.³

This is a very stylized model, in which many important features of the Securities Clearing and Settlement industry are missing,⁴ but it allows to do a first pass at the welfare consequences of vertical integration. The two custodian banks compete to provide differentiated services tailored to satisfy the needs of final investors. This product differentiation dimension is captured by a Hotelling model (a standard modelling tool in Industrial Organization, see for example Tirole (1988)) where investors are located on a unit interval $[0,1]$, and incur a transportation cost per unit of distance when they choose to patronize one of the custodian banks, located at the extremes of the unit interval. This model is represented in Figure 1 when the CSD is independent from the banks (CSD model) and in Figure 2 when bank 1 and CSD are integrated (the ICSD model).

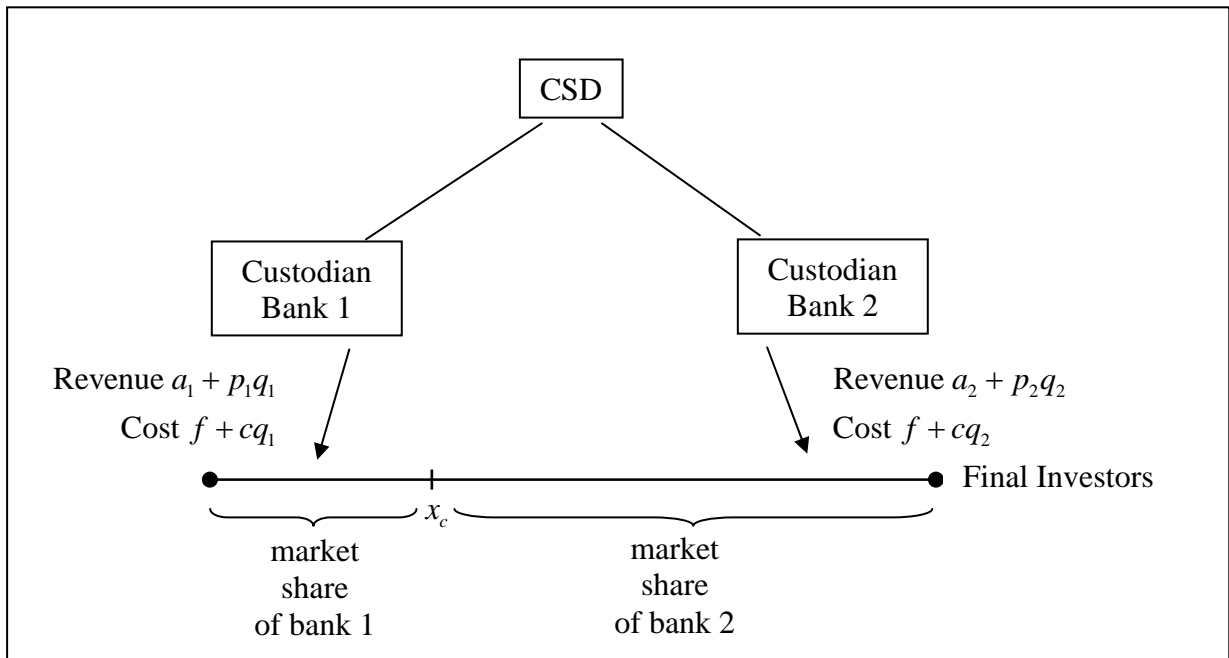


Figure 1: The CSD model.

The net utility of a final investor who decides to patronize bank i is :

$$U_i = v(q) - (p_i q + a_i) - t x_i, \quad (1)$$

where q represents the number of transactions undertaken by the investor during the relevant time period (say, a year), $v(q)$ is the gross surplus generated by these q transactions (where v is increasing, concave and satisfies $v(0) = 0$), p_i is the unit fee charged (per transaction) by custodian bank i ($i = 1, 2$), a_i is the fixed fee charged by custodian bank i for maintaining a

³ Some CSDs, such as Montetitolì in Italy, also provide complementary services.

⁴ Such as the roles of the exchange, the central counterparty (CCP), broker-dealers and agent banks.

customer's account during the relevant time period (say, a yearly fee) and x_i is the "distance" between the customer's need and the services provided by custodian bank i . Finally, t is a "transportation cost", or differentiation parameter, that reflects the intensity of competition between custodian banks. The higher t , the more differentiated the services offered by the two banks, and thus the less competitive the downstream market. Provided that he chooses bank i , the final investor selects the number q_i of transactions in order to maximize its net surplus:

$$\max_q (v(q) - p_i q) \equiv S(p_i), \quad (2)$$

where the maximum is obtained for $q_i = D(p_i)$. $D(\cdot)$ can be considered as the demand function of each final investor.⁵ It is a decreasing function, that can be defined as the inverse of the marginal gross surplus $v'(q)$:

$$q = D(p) \Leftrightarrow p = v'(q). \quad (3)$$

Once he has optimized his volume of transactions as a function of the unit price charged by each bank, each investor can compare the net utilities provided by the two banks:

$$U_i = S(p_i) - a_i - tx_i, \quad i = 1, 2. \quad (4)$$

The difference in these utilities is:

$$\Delta U \equiv U_1 - U_2 = [S(p_1) - a_1 - tx_1] - [S(p_2) - a_2 - tx_2].$$

Given that $x_1 + x_2 = 1$ (since the custodian banks are located at the extremes of the unit interval), this difference is also equal to:

$$\Delta U = [S(p_1) - s(p_2)] - [a_1 - a_2] - t(2x_1 - 1). \quad (5)$$

Thus the customer will choose bank 1 if and only if:

$$\Delta U \geq 0 \Leftrightarrow x_1 \leq x_c \equiv \frac{1}{2} + \frac{1}{2t} [S(p_1) - S(p_2) - a_1 + a_2]. \quad (6)$$

Provided t is not too large, and the prices charged by the custodian banks are not too high, all the market will be served, and the market shares of the two custodian banks will be, respectively, x_c and $1 - x_c$.

We now proceed by determining the competitive equilibrium of the banking industry, depending on the type of relations prevailing between the CSD and the custodian banks. We consider in turn two different industry structures:

- In the first structure, which we call the CSD model, the CSD is independent. It independently contracts with the two custodian banks.

⁵ In the present version of the model, this demand function is the same for all users. However, we can easily introduce a second category of final users, namely broker dealers, having a much higher demand for trade.

- In the second structure, which we call the ICSD model, the CSD is integrated with one of the custodian banks and may be able to exclude the other bank.

4- *The CSD Model*

In this section, we consider the case where the CSD is independent from the custodian banks, and contracts with each of them for the provision of settlement services. The cost structure is as follows: the CSD incurs a fixed cost F and a variable cost CQ for providing depository and settlement services to each custodian bank (for a volume of transactions Q); each custodian bank incurs a fixed cost f and a variable cost cq for providing complementary services to each of his final customers (for a volume of transactions q). A crucial assumption of our model is that it would be socially inefficient to let several CSDs compete for the provision of depository and settlement services⁶ for **a given security** (natural monopoly property). This comes from the property of increasing returns to scale that seems to be confirmed by empirical analysis (see Schmeidel et al., 2004 or Van Cayseele and Wuyts (2005) However, this does not necessarily mean that a unique CSD would be optimal **at the industry level**. Even though several CSDs compete, it would be total uneconomical to have the same security deposited in several CSDs. Therefore when final investors want to trade in a given security, they are obliged to access (directly or indirectly) the (unique) CSD that provide notary services for this particular security. This is what as been called a competitive bottleneck situation (see for example Bergman, 2003): analogous to the local loop in the telecom industry.⁷ Assuming that the CSD is not for profit⁸ and uses a cost-based fee structure, one can show (see the Appendix) that the outcome of the contracting game is as follows:

Result 1: *Competition between custodian banks in the CSD model results in the following prices:*

$$p_1 = p_2 = c + C, \quad (7)$$

(per transaction prices charged by custodian banks equal their total marginal cost)

$$a_1 = a_2 = f + t, \quad (8)$$

(fixed fees charged by custodian banks equals their fixed cost f of managing each customer's account plus the differentiation cost parameter, that measures the intensity of downstream competition).

⁶ Milne (2004) argues that the natural monopoly property only applies to depository services, while settlement services can be provided by competitive providers. However, in his comments on the US-DTC (p. 45) he argues that "the horizontal integration of US clearing and settlement seems to have yielded major benefits.

⁷ Van Cayseele (2005) argues that CSDs are in a natural oligopoly situation. This may be true at the industry level but neglects the bottleneck problem.

⁸ For an analysis of the impact of vertical integration in the for profit case see Rey-Tirole (2003).

The welfare analysis of the CSD case is then straightforward. Social welfare equals the difference between net investors' surplus and the sum of fixed costs and aggregate differentiation costs:

$$W_{CSD} = S(c + C) - f - 2F - \frac{t}{4}. \quad (9)$$

This total welfare is shared as follows:

- average consumer surplus equals:

$$U_{CSD} = S(c + C) - f - \frac{5t}{4}, \quad (10)$$

- custodian banks make a profit equal to: $\pi_B = \frac{t}{2} - F$,
- the CSD makes a zero profit.

All the final investors are served, and the market is equally shared between the two custodian banks.

Two conditions have to be satisfied for this characterization to be valid:

- $t > 2F$: The customers' valuation for the differentiation of services provided by the custodian banks (measured by the parameter t) has to be strong enough so that the profits of custodian banks (which are ultimately collected by the CSD) cover the fixed costs of the CSD for servicing these custodian banks.
- $S(c + C) > f + \frac{3t}{2}$: The gross surplus of each final investor has to exceed the sum of fixed costs for maintaining the investor's account with the bank, the margin t of the custodian bank and the maximal transportation cost $\frac{t}{2}$ incurred among investors. Without this condition, the downstream market would not be fully served.

Let us consider now the alternative market structure where the CSD integrates vertically with one of the custodian banks.

5- *The ICSD Model*

We assume in this section that the CSD merges with custodian bank 1 (and thus becomes an ICSD) and selects directly the two part tariff offered to the customers of bank 1. The ICSD may also decide to offer clearing and settlement services to bank 2, or else to exclude bank 2. This second case is represented in Figure 2.

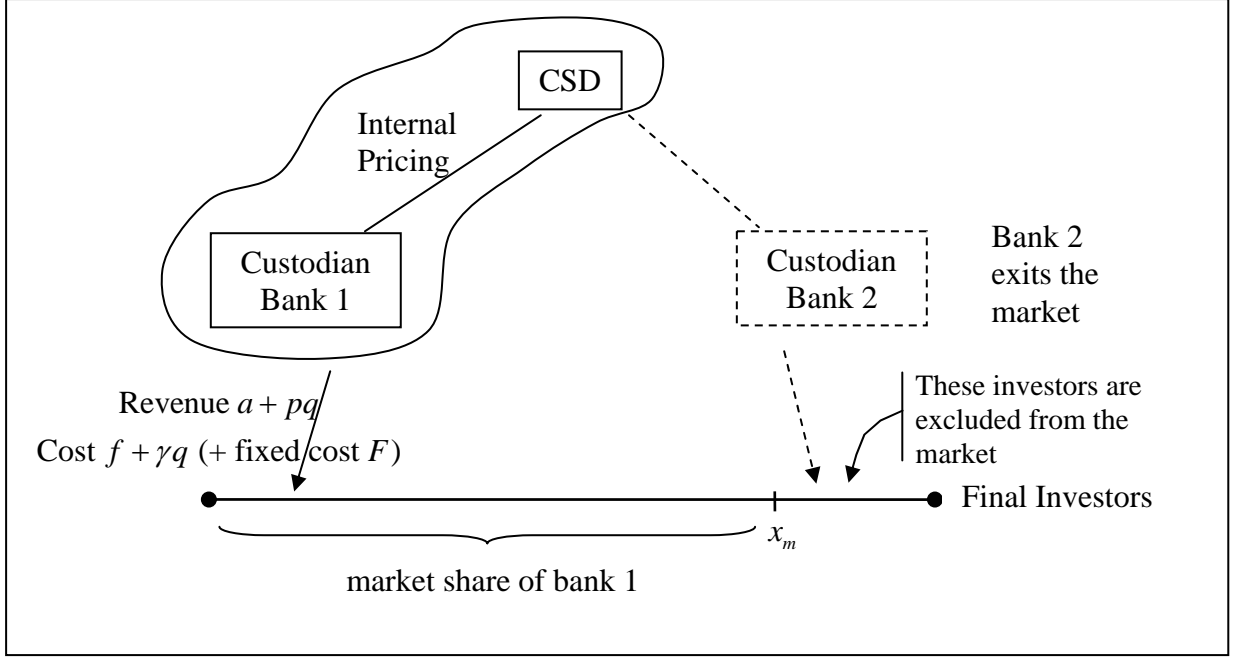


Figure 2: The ICSD model (in the case of foreclosure of bank 2).
The dotted lines indicate inactive links.

Let us first analyse this latter case. We assume that the merger is accompanied by a decrease in total marginal cost from $c + C$ to γ , due to the internalisation of some trades and/or technological improvements.⁹

5.1- Exclusion of Bank 2

The profit of the ICSD is then given by

$$\pi_{ICSD} = x_m [a - f + (p - \gamma)D(p)] - F, \quad (11)$$

where x_m equals the market share of the ICSD, determined by the distance to bank 1 of the marginal investor, i.e. the final investor who obtains a zero surplus:

$$S(p) - a - tx_m = 0. \quad (12)$$

Replacing a by its value given by (13), we can rewrite the profit of the ICSD as:

$$\pi_{ICSD} = x_m [S(p) - tx_m - f + (p - \gamma)D(p)] - F.$$

After rearranging terms (using the fact that $S(p) + pD(p) = v[D(p)]$) we get:

⁹ Notice also that the nature of the settlement service is modified by this vertical integration. Indeed, the payment underlying the settlement of a security trade in a CSD is done in central bank money. By contrast, when the settlement is performed by an ICSD, the payment is settled in commercial bank money, which may be the source of systemic risk. This aspect is not modelled here.

$$\pi_{ICSD} = x_m [v(q) - \gamma q - f - tx_m] - F,$$

where $q = D(p)$. The maximum profit is obtained when

$$p \equiv v'(q) = \gamma \text{ (marginal cost pricing).}$$

The profit of the ICSD can thus be written:

$$\pi_{ICSD} = \max_{x_m \leq 1} x_m [S(\gamma) - f - tx_m] - F. \quad (13)$$

When $S(\gamma)$ is large enough (more precisely, larger than $f + 2t$), the ICSD chooses to serve all the downstream market ($x_m = 1$) and the market equilibrium can be compared easily with the previous one (corresponding to the CSD case).

- All final investors are served in both cases.
- The per transaction price is lower in the ICSD case: $p_{ICSD} = \gamma < p_{CSD} = c + C$. This is because we have assumed that the merger entailed a decrease in the total marginal cost of transactions.
- The fixed fee paid by investors is higher in the ICSD case:

$$a_{ICSD} = S(\gamma) - t > a_{CSD} = t + f.$$

(this is because by assumption $S(\gamma) > f + 2t$).

- Custodian bank 2 disappears, which decreases the variety of services offered to final investors, and in particular decreases the net surplus of the former customers of bank 2.

Social welfare in the ICSD situation can be computed easily:

$$W_{ICSD} = S(\gamma) - f - F - \frac{t}{2}. \quad (14)$$

Comparing with formula (9), which gives social welfare in the CSD case, we see that the trade-off is between the cost reductions due to the merger (marginal costs are reduced from $c + C$ to γ , fixed costs are reduced by F , due to the exit of one intermediary, namely bank 2) and the increase in aggregate differentiation costs from $\frac{t}{4}$ to $\frac{t}{2}$ (also due to the exit of bank 2). This is summarized as follows:

Result 2: *When the ICSD is allowed to exclude bank 2, the equilibrium of the clearing and settlement industry is characterized by the following features:*

- The per transaction price is lower than in the CSD case. This favours brokers and dealers, who are characterised by a large volume of trading.
- The fixed fee paid by investors is higher than in the CSD case. This penalizes small investors, who are characterized by a small volume of trading.
- Social welfare may be higher or lower than in the CSD case, according to which of the following opposing effects dominates:
 - increase in technical efficiency due to the merger of the CSD with custodian bank 1,
 - decrease in competition due to the exit of bank 2.

Of course the exclusion of bank 2 by the ICSD hurts a fraction of final users (most of the former customers of bank 2). This is why regulators may be tempted to allow the merger between the CSD and bank 1 only if bank 2 keeps an open access to the CSD, and for a "reasonable" access charge. We now study this possibility and analyze the case where regulators mandate the ICSD to service bank 2 for a cost-based fee $F + CQ_2$.

5.2- Open access of bank 2 to the ICSD

We assume in this section that regulation imposes that the ICSD offers open access to settlement services for a cost-based fee. The situation is represented in Figure 3.

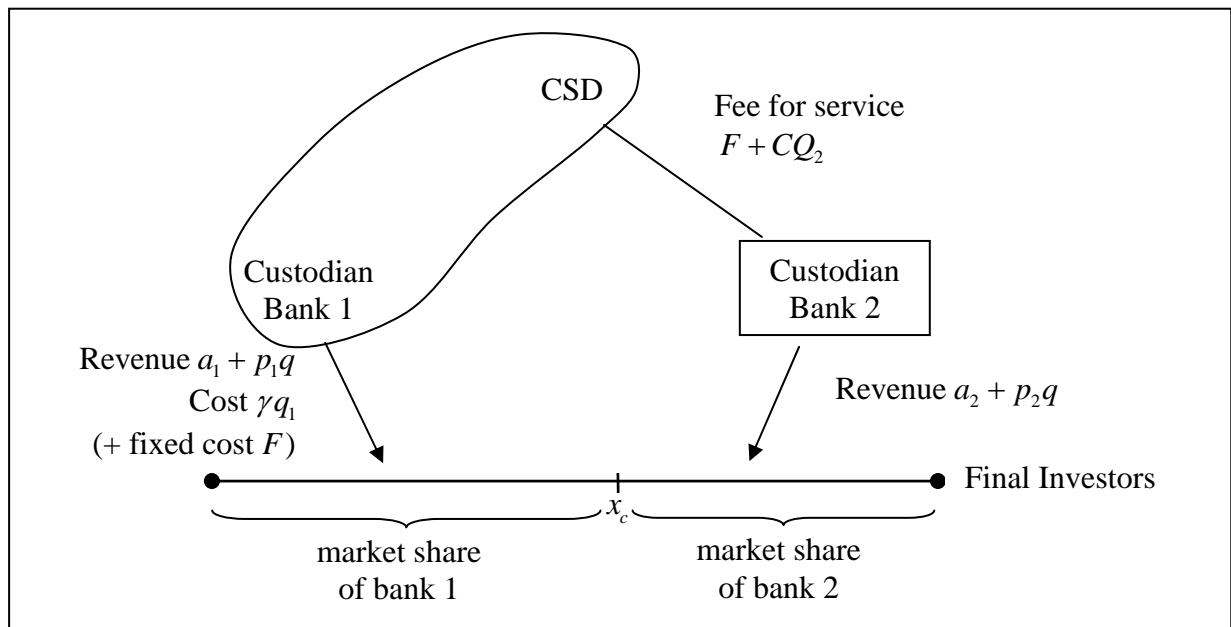


Figure 3: The ICSD model
(in the case where bank 2 has open access to the platform)

Assuming that the ICSD is constrained by regulation to make no profit on its CSD activity towards bank 2, the profit of the ICSD is given by:

$$\pi_{ICSD} = x_c [a_1 - f + (p_1 - \gamma)D(p_1)] - F, \quad (15)$$

where the market share x_c is determined like in formula (6):

$$x_c = \frac{1}{2} + \frac{1}{2t} [S(p_1) - S(p_2) - a_1 + a_2].$$

The profit of custodian bank 2 is:

$$\pi_2 = (1 - x_c) [a_2 - f + (p_2 - c - C)D(p_2)] - F. \quad (16)$$

The following result is proven in the Appendix:

Result 3: *When the competitor bank has open access to the ICSD, the equilibrium of the clearing and settlement industry is characterized by the following features:*

- *The per transaction price is lower for the ICSD than for bank 2, which keeps the same per transaction price as in the CSD case. Again, this favors brokers and dealers.*
- *The fixed fee of the ICSD is higher than that of bank 2, which is reduced in comparison with the CSD case.*
- *The market share of the ICSD increases, and that of bank 2 decreases.*
- *Social welfare increases.*

6- *Potential problems fro regulators*

Our result 3 shows that, in principle, a cost-based regulation of access to the CSD part of an ICSD could restore efficiency of competition in the banking industry. However, such a regulation could be confronted with potential difficulties.

First of all, the ICSD does not have any incentive to reveal its costs to the regulator, since regulation leads to a substantial decrease in its profits. This means that the regulator would have the resort to a combination of monitoring and incentive regulation (which are both costly) in order to extract from the ICSD the information on costs that is needed.

Moreover regulation would also require to implement a true accounting and governance separation between the ICSD and its banking subsidiary, potentially losing some of the scope economies. In any case, it could be difficult for the regulator to separate the costs of depository and settlement services from the costs of associated banking services.

More importantly, CSDs have another kind of final users (namely issuing firms) that have been so far neglected in the analysis. The clearing and settlement industry is a two-sided

market (see Rochet and Tirole (2003), with important indirect externalities between the two kinds of final users: final investors and issuers. In particular, final investors benefit from a larger number of issuers present in a given CSD. In such a case, economic analysis (see Rochet and Tirole (2003) shows that cost based regulation of access does not lead to the socially optimal outcome: cross subsidies between investors and issuers may be needed to stimulate issuing. An ICSD would partially internalize these indirect externalities but would charge high mark up, leading to an insufficient number of issuers.

7- Conclusion

This paper is a first attempt to analyze the welfare effects of vertical integration between a CSD and a custodian bank in the securities clearing and settlement industry. It shows that a move from the CSD model to the ICSD model is likely to induce redistributive effects benefiting brokers and dealers and penalizing retail investors. This is because vertical integration is likely to entail a decrease in marginal costs of settlement (leading to a possible decrease in per transaction fees) accompanied with a decrease in competition for providing services to final users (leading, on average, to an increase in the fixed fees charged to investors).

A possible way to avoid these undesirable consequences is to require accounting and governance separation between the ICSD and its banking subsidiary and to oblige it to grant open access to its infrastructure to competing custodian banks, with a cost-based regulation of access prices.

However such a regulatory system might be confronted with practical difficulties, such as the extraction from the ICSD of the necessary information about its costs and also the separation of the costs of depository and settlement services from those of complementary banking services. More importantly, indirect externalities with the other side of the market (issuing firms) may imply that cost-based regulation is not an appropriate benchmark.

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APPENDIX: Technical Proofs

Proof of Result 1: The profit of bank 1 is

$$\pi_1 = [a_1 + (p_1 - c)D(p_1) - f - CD(p_1)]x_c - F,$$

where x_c is given by formula (6):

$$x_c = \frac{1}{2} + \frac{1}{2t} [S(p_1) - S(p_2) - a_1 + a_2].$$

For given prices (a_2, p_2) chosen by bank 2, the profit of bank 1 is maximized when

$$\frac{\partial \pi_1}{\partial a_1} = \frac{\partial \pi_1}{\partial p_1} = 0.$$

Now simple computations give:

$$\frac{\partial \pi_1}{\partial a_1} = x_c + [a_1 + (p_1 - c)D(p_1) - f - CD(p_1)] \frac{\partial x_c}{\partial a_1},$$

and

$$\frac{\partial \pi_1}{\partial p_1} = [D(p_1) + (p_1 - c - C)D'(p_1)]x_c + [a_1 + (p_1 - c)D(p_1) - f - CD(p_1)] \frac{\partial x_c}{\partial p_1},$$

where, by formula (6):

$$\frac{\partial x_c}{\partial a_1} = -\frac{1}{2t} \quad \text{and} \quad \frac{\partial x_c}{\partial p_1} = \frac{S'(p_1)}{2t} = -\frac{D(p_1)}{2t}.$$

At the equilibrium of the banking industry we have by symmetry: $p_1 = p_2$, $a_1 = a_2$ and $x_c = 1/2$. Thus:

$$t = [a_1 + (p_1 - c - C)D(p_1) - f] = t \left[1 + (p_1 - c - C) \frac{D'(p_1)}{D(p_1)} \right].$$

Thus $p_1 = p_2 = c + C$; $a_1 = a_2 = f + t$. ■

Proof of Result 3: The Profit of the ICSD is maximum (for given prices (a_2, p_2) chosen by bank 2) when the first order conditions are satisfied:

$$\frac{\partial \pi_{ICSD}}{\partial a_1} = \frac{\partial \pi_{ICSD}}{\partial p_1} = 0.$$

Using formula (15) we obtain easily:

$$p_1 = \gamma \quad \text{and} \quad a_1 = f + 2tx_c.$$

Similar computations for bank 2 give:

$$p_2 = c + C \quad \text{and} \quad a_2 = f + 2t(1 - x_c).$$

Solving for x_c we obtain:

$$x_c = \frac{1}{2} + \frac{1}{6t} [S(\gamma) - S(c+C)] > \frac{1}{2}, \quad (\text{A1})$$

and

$$a_1 = f + t + \frac{1}{3} [S(\gamma) - S(c+C)],$$

$$a_2 = f + t - \frac{1}{3} [S(\gamma) - S(c+C)].$$

Thus we see that the transaction price is lower for the ICSD than for bank 2:

$$p_1 = \gamma < p_2 = c + C.$$

Moreover the market share of the ICSD increases from $\frac{1}{2}$ to x_c and that of the CSD decreases from $\frac{1}{2}$ to $1 - x_c$.

The formulas for fixed fees then imply that

$$a_1 < f + t < a_2.$$

Social welfare can be computed as follows:

- a fraction x_c of the final users get a lower price γ to the ICSD, and thus an aggregate net surplus of:

$$x_c \left[S(\gamma) - \frac{t}{2} x_c \right]$$

- a fraction $(1 - x_c)$ of the final users get a higher price $c + C$ at bank 2, and thus an aggregate net surplus of:

$$(1 - x_c) \left[S(c + C) - \frac{t}{2} (1 - x_c) \right]$$

- the profit of the ICSD is

$$\pi_{ICSD} = 2tx_c^2 - F$$

- the profit of bank 2 is

$$\pi_2 = 2t(1 - x_c)^2 - F.$$

Thus social welfare equals

$$W_{ICSD} = S(c + C) + x_c [S(\gamma) - S(c + C)] - \frac{5}{2} t [x_c^2 + (1 - x_c)^2] - f - 2F.$$

Comparing with formula (9), we see that

$$W_{ICSD} - W_{CSD} = x_c [S(\gamma) - S(c + C)] - \frac{5}{2} t [x_c^2 + (1 - x_c)^2] + \frac{5}{4} t.$$

Now we can replace $S(\gamma) - S(c + C)$ by $6t[x_c - 1/2]$ (see formula A1). Thus:

$$\begin{aligned}
W_{ICSD} - W_{CSD} &= t \left[6x_c^2 - 3x_c - \frac{5}{2}(2x_c^2 - 2x_c + 1) + \frac{5}{4} \right] \\
&= t \left[x_c^2 + 2x_c - \frac{5}{4} \right] = t \left[x_c - \frac{1}{2} \right] \left[x_c + \frac{5}{2} \right].
\end{aligned}$$

Whenever $\gamma < c + C$, $x_c > 1/2$ (see formula A1) and thus

$$W_{ICSD} > W_{CSD}.$$

A similar computation shows that total user surplus increases by

$$\Delta U = 3 + \left(x_c - \frac{1}{2} \right) \left(\frac{3}{2} - x_c \right),$$

while the industry's profit increases by

$$\Delta \pi = 4t \left(x_c - \frac{1}{2} \right)^2.$$

■