Vertical Integration, Competition, and Financial Exchanges: Is there Grain in the Silo?∗

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Abstract

We investigate the incentives for vertical or horizontal integration in the financial securities service industry. Our analysis shows that the incentives for vertical integration depend on industry characteristics revealing, for example, that incentives increase in the demand for liquidity. Decentralized decisions might lead to an industry equilibrium with lower aggregate profits for all participants. This coordination problem can be overcome by horizontal integration. By linking our results to recent regulatory and institutional developments we argue that multilateral trading facilities and algorithmic trading should lead to less vertical integration, while the regulatory push towards bringing over-the-counter trades on organized exchanges has the opposite effect.

Keywords: vertical integration, horizontal integration, competition, trading, settlement

JEL classification: G15, L13, L22

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1 Introduction

The securities exchanges and central securities depositories (CSDs) that are at the center of modern capital markets are confronted with what seems to be a permanent debate about their organizational structure (see e.g. FESE (2010)) and with attempts to change this organizational structure. Prominent examples of such attempts are the recent horizontal merger of NYSE Euronext and Deutsche Boerse, which failed because of antitrust concerns as well as the planned merger of Deutsche Boerse with Euronext in 2008. The main reason the Deutsche Boerse/Euronext merger was not finalized in 2008 was strong doubts of Deutsche Boerse’s investors (hedgefunds TCI and Atticus) concerning the vertically integrated structure of Deutsche Boerse, which led the investors to block the merger. They argued that it would be more valuable to split up Deutsche Boerse into one trading and one post-trading company and merge these firms on a horizontal level.

Until now, across continents and markets, we observe very different industry structures. On the one hand, we find a much more fragmented structure in Europe with roughly 20 exchanges and CSDs (see FESE (2010)) compared to the U.S. market, which has only a dozen exchanges and two CSDs. On the other hand, the degree of vertical integration differs significantly among European countries and markets. For example, we see strong vertical integration in Germany and less vertical integration in other markets such as the United Kingdom.

Against this background, we provide insights on the dynamics of the industrial organizations of the financial securities service industry, most notably on the interrelation of organizational design and market structure. Our main research questions focus on examining under what circumstances vertical integration is profitable, and when horizontal integration outcompetes vertical integration from the viewpoint of both firms and society. We further ask for the implications of current industry and regulatory trends on the organizational design of the financial securities service industry.

We use these general research questions to investigate the drivers behind vertical and horizontal integration in the financial securities service industry. We show that due to negative externalities on competitors, individual incentives to vertically integrate may lead to a full vertical integration equilibrium, which is associated with lower firm profits. We find that horizontal integration dominates in such situations, leading to horizontal rather than vertical integration in these cases. This result gives a further justification to the TARGET2-Securities initiative of the Eurosystem which tries to implement compatible systems among CSDs.

On the basis of our general analysis we derive testable hypotheses that are directed towards major developments in the industry. Our analysis leads us to expect that the emergence of multilateral trading facilities will lower the incentives to vertically integrate.
We conjecture that the same is true with respect to the growth in algorithmic trading. Because algorithmic trading provides liquidity to exchanges and hence reduces the liquidity advantage of home markets, the incentives to trade and settle in a vertical silo diminish. Also, more over-the-counter (OTC) trading is associated with fewer incentives to build up silos.

To derive these results, we use a stylized model that depicts the interrelation between the organizational design of financial securities service providers and the competition among them. The model incorporates economies of scope and network effects at the different levels of the value chain of the financial securities service industry. We assume that vertical integration makes it possible to implement a highly specific relation between an exchange and the associated CSD. Although this highly specific link makes trades routed through it less costly, it imposes additional costs to trades that are either settled outside the associated CSD or traded on another exchange but settled in the associated CSD. It also resembles the idea of vertical integration as a decision for a closed rather than an open standard that makes external linkages partially incompatible with internal processes. Hence, our interpretation of vertical integration is on the one hand in line with the information we have received from many industry experts in the course of a number of interviews and discussions, and on the other hand conforms with the basic arguments from the theory of firm literature in the tradition of Grossman and Hart (1986). To our knowledge we are the first using such an approach in discussing the incentives for vertical integration in network industries.

Our paper is related to several strands of the literature on the financial securities service industry. First, our paper touches on the topic of competition between exchanges. This topic is analyzed in different manners by, e.g., Foucault and Parlour (2004), Di Noia (2002), and Shy and Tarkka (2001) where Shy and Tarkka (2001) also involve a vertical relation between the brokers and stock exchanges. But their paper centers on the role of alliances between stock exchanges, i.e., they examine cooperation on a horizontal level. Second, we apply analogies to the question of interlinking securities settlement systems as is analyzed by Kauko (2004) and Kauko (2007). Third, our work is directly related to the literature on vertical integration in the financial securities service industry. Köppl and Monnet (2007) analyze the role of private information in a merger between a stock exchange and a settlement provider and show that vertical silos can prevent efficient consolidation on a horizontal level. In contrast, Holthausen and Tapking (2007) and Rochet (2005) model the vertical relation between custodian banks and a CSD. In Holthausen and Tapking (2007) the CSD is both input provider and competitor. These authors show that the CSD leverages its monopoly power to compete for customers at the custodian level by raising its rivals’ costs. Rochet (2005) asks if a CSD should be allowed to integrate
vertically with custodian banks. Rochet (2005) concludes that the welfare effect of such a merger hinges on the trade-off between efficiency gains and lower competition on the custodian level that are due to the merger. This trade-off is also at the center of attention in our paper as well, but we focus on a different aspect of the value chain, one which involves very different economic mechanisms.

The paper closest to our analysis is Tapking and Yang (2006). These authors analyze different industry settings in the sense of vertical or horizontal integration in a two-country model. They conclude that from a social perspective horizontal integration dominates vertical integration, which itself is better than no consolidation. Tapking and Yang (2006) ask “... under which conditions a merger of CSDs is welfare improving” and do not discuss “whether under these conditions, market forces would indeed result in a merger” (Tapking and Yang (2006), p. 1772). In contrast, we investigate the issue of vertical and horizontal integration from the viewpoint of the exchange, i.e., private firms and their investors.

The paper is organized as follows. In section 2 we shortly outline the structure of the industry and present the basic model. Using this basic model, in section 3 we discuss the incentives and consequences of vertical integration and derive further the equilibrium of the vertical integration decision. In section 4, we compare vertical with horizontal integration. In section 5 we derive several testable hypotheses from our model, thereby merging our analysis with recent key industry developments. In section 6 we conclude.

2 The basic model

Before we outline the basic model, we present the characteristics of the financial securities service industry on which we build our model. We describe the relevant functions needed to process a trade and the main providers of these processes along the value chain.

2.1 Institutional background

The securities transaction process is basically characterized by three functions. The first function is the actual trading process, e.g., the matching of buyer and seller which usually takes place on the exchanges, alternative trading platforms, or via over-the-counter one-to-one trading. Since traders want to minimize the influence of their orders on the price, liquidity matters a lot at this stage.

The second function is the clearing process. In this process, the bi-/multilateral obligations are calculated by the clearing house, which in recent years has more frequently involved a Central Counterparty (CCP). Usually the clearing house is owned by the exchange.

The third function is the settlement process in which transactions are completed and
the cash and securities are transferred. This service is offered for each particular security by monopolistic central securities depositories (CSDs) that hold the security and allow transactions by book entry. Since systems can be used for different securities, and cash settlements might be netted, economies of scope are present at this stage. Beside CSDs also custodian banks offer these services and take the role of an intermediary. They usually have an account at the main CSDs that allows their customers to trade securities kept at different CSDs (usually different countries) via one account.

Furthermore the CSDs offer safe-keeping for securities, e.g., the distribution of information by the security issuer, dividend flow, etc. The safe-keeping is needed to allow transactions but, unlike other processes, it is not necessarily involved in every transaction.

If an entity owns the providers of all three transaction services, then it is described as a vertically integrated exchange or a silo.

Given that we incorporate industry-specific characteristics such as the nature of network effects or the monopoly position of the CSDs, we view our model as an analysis of the securities trading industry rather than as a general analysis of the pros and cons of vertical and horizontal integration in network industries in general. There are very few other papers discussing (vertical or horizontal) integration decisions in network industries. Exceptions to this are Church and Gandal (2000) and Dogan (2009) who focus on compatibility between networks on the demand side while we consider compatibility on the supply side.

2.2 The model setup

We consider a setting in which three exchanges \( i = A, B, C \) compete with each other. Besides the three exchanges, there exist three CSDs \( j = A, B, C \). These CSDs may or may not be vertically integrated with the exchanges. We use a framework with three exchanges/CSDs to allow for non-covered markets. Doing so enables us to analyze the effect of vertical or horizontal integration on the level of total liquidity of a security, a basic ingredient of our model.

**Exchanges and CSDs:** Clearing services are provided by the exchanges and therefore are not considered separately. The costs to trade one unit of a security are identical across all three exchanges and are denoted by \( c^T \), the cost of settlement for a trade originated on exchange \( j \) and settled in CSD \( i \) is \( c^S \) (\( i, j = A, B, C \)). A security that is listed on a particular exchange (for instance, A) is kept in the respective CSD (in this case, A), implying that a given security can be traded on different exchanges but settled in only one CSD. This fact gives CSDs monopoly power for a particular security. We assume perfect competition between custodian banks and therefore do not consider them in our analysis.
Introducing them into our model and allowing them to provide links to different CSDs would not alter our qualitative analysis.

We normalize the total number of securities to one. We allow for a symmetric set-up, setting the number of securities listed on either exchange to one third. Traders are uniformly distributed on the perimeter of a circle with a length equal to one and a density equal to one. All traders demand inelastically one unit of each security listed on any of the three exchanges. The reservation price for all traders for trading and settlement services is denoted by $V$. This reservation price includes the price of the security traded. Because we are only interested in the overall number of trades rather than the bilateral relation between seller and buyer, we assume that this reservation price is identical for all traders. The three exchanges and the corresponding CSDs are symmetrically located on the perimeter of the circle at zero, one third and two thirds (see Figure 1).

Our analysis is based on the idea that the market is not fully covered. Hence, we leave room for market coverage effects in order to allow vertical integration to affect trading volume. We also avoid having CSDs face a price-inelastic demand with all the special features of such a specific demand curve. Our no-full-coverage assumption is in line with the clearly observed home bias (see, e.g., Tesar and Werner (2008)) under which investors focus more heavily on local securities, for example by concentrating on the (perceived) costs of price dispersion and the (perceived) informational advantages from buying local assets. In the absence of fully covered markets, investors are more likely to trade local securities compared to securities listed on other exchanges.

Although CSDs can price-discriminate between trades originated at different exchanges, exchanges can only charge one price for securities kept at different CSDs. This assumption is not only justifiable in relation to current practice but also because regulations make it very difficult for exchanges to discriminate against investors on the basis of their settlement provider. In contrast, CSDs can observe trades originated on different exchanges and hinder arbitrage from occurring: hence, they are able to price-discriminate. Although the no-discrimination assumption for exchanges is not decisive for our analysis, the ability of CSDs to price-discriminate is important for our argument for vertical integration. But this assumption is even more natural, since it only requires that CSDs can charge different prices vis-a-vis their respective exchanges as compared to arm’s length transaction with the competing exchange. We denote the price of CSD $i$ for trades taking place on exchange $j$ by $p_{ij}^e$, $p_i^T$ stands for the price of exchange $i$.

**Traders:** The further away a trader is located from the exchange on which he is actually trading, the higher is the disutility he realizes from the trade. Suppose a trader is located at $x$ and trades on exchange $i$. We define the closest distance between the
trader and the exchange as $g_i^1$. Then, the trader realizes a disutility of $tg_x^j$ where $t$ denotes the degree of differentiation across the exchanges. This disutility term reflects the idea that there are differences across exchanges that stem from locational differences, such as language, regulation, and the like. The more pronounced these differences are, the larger is $t$. We interpret this parameter $t$ as the degree of financial market integration. We note that these differences usually take the form of discrete steps. Our continuous set-up reflects the fact that these features have different levels of importance for different kinds of traders (institutional, private, high-frequency). These varying perceptions of the differences are taken into account by a continuous function, which keeps the model also tractable.

We assume that traders have to pay both prices and expect the exchange on which the security is listed as being the more liquid one. The latter assumption increases the utility of traders trading on the “home” exchange by $k$. This assumption is in line with the observation of Halling, Pagano, Randl, and Zechner (2008) that the liquidity of a stock is usually concentrated on the stock exchange where the company has its primary listing. In the following, we refer to $k$ as the liquidity parameter. We are aware that for a full understanding of the competition between exchanges the role of the liquidity should be endogenous. But since we are interested in the organization decision we believe that this short-cut is sufficient.

Therefore, we can state the utility of a trader being located at point $x$ on the circle who considers buying one unit of a security that is listed on exchange A as:

$$U^A_x = \begin{cases} 
V - p_A^T - p_{AA}^S + k - tg_x^A & \text{if trading takes place on exchange A} \\
V - p_j^T - p_{Aj}^S - tg_x^j & \text{if trading takes place on exchange } j \ (j = B, C) 
\end{cases}$$ (1)
If securities are listed on exchanges B or C the corresponding utility functions apply.

**Demand:** Therefore, we can derive the total demand of the exchange on which the security is listed (say, A) as the sum of the two marginal traders ($x^A_1$ and $1-x^A_1$, see figure 1) being located between this exchange, and the two exchanges with which it competes (B and C). We derive total demand for the two remaining exchanges from the sum of the respective demand accruing to these exchanges when competing with exchange A ($\frac{1}{3} - x^A_1$ for exchange B and $x^A_2 - \frac{2}{3}$ for exchange C) and the respective demand that arises from the marginal traders on exchanges B and C, who are indifferent between buying or not buying at all ($x^A_3 - \frac{1}{3}$ for exchange B and $\frac{2}{3} - x^A_4$ for exchange C, to which we refer as the backyard).

Deriving the marginal traders yields the following demand functions:

\[
d^A_{AB} = x^A_1 = \frac{p^T_B - p^T_A + p^S_{AB} - p^S_{AA} + k + \frac{1}{3}t}{2t} \quad (2)
\]
\[
d^A_{AC} = 1 - x^A_2 = \frac{p^T_C - p^T_A + p^S_{AC} - p^S_{AA} + k + \frac{1}{3}t}{2t} \quad (3)
\]
\[
d^A_{BA} = \frac{1}{3} - x^A_1 = \frac{p^T_A - p^T_B + p^S_{AA} - p^S_{AB} - k + \frac{1}{3}t}{2t} \quad (4)
\]
\[
d^A_{CA} = x^A_2 - \frac{2}{3} = \frac{p^T_A - p^T_C + p^S_{AC} - p^S_{AC} - k + \frac{1}{3}t}{2t} \quad (5)
\]
\[
d^A_{BB} = x^A_3 - \frac{1}{3} = \frac{V - p^T_B - p^S_{AB}}{t} \quad (6)
\]
\[
d^A_{CC} = \frac{2}{3} - x^A_4 = \frac{V - p^T_C - p^S_{AC}}{t} \quad (7)
\]

with $d^A_{ij}$ denoting the demand for trades on exchange $i$ of securities listed on exchange A when competing with exchange $j$.

The total demand for trades on each exchange for a security listed on exchange A emerges as $d^A_A = d^A_{AB} + d^A_{AC}$, $d^A_B = d^A_{BA} + d^A_{BB}$, and $d^A_C = d^A_{CA} + d^A_{CC}$. If trading for a security takes place on exchange B or C, then we can derive demand functions by replacing A with the respective exchange on which the security is listed.

Hence, we can state the profit function of the exchanges as:

\[
\pi^T_i = \frac{1}{3}(p^T_i - c^T) \sum_j d^T_j,
\]

and that of the CSDs as:

\[
\pi^S_i = \frac{1}{3} \sum_j (p^S_{ij} - c^S_{ij}) d^S_j.
\]

We impose an assumption that ensures that the market is not fully covered which avoids having aggregate demand be completely price-inelastic. Two further assumptions on our
parameter range imply that standard Salop-type competition occurs between the exchanges. For a security listed on exchange $i$ the first assumption requires that $x^i_3 < x^i_4$ which is stated in the first part of Assumption 1. The first regularity condition for Salop-type competition requires that the competition between exchanges takes place for the marginal trader who is located in between these exchanges, i.e., $x^i_1 < 1/3$ and $2/3 < x^A_2 < 1$ (part 1 of Assumption 2). Furthermore, our second regulatory condition requires that as usual in Salop-models the surplus generated by a trade needs to be positive for the marginal trader being located between the exchanges (see parts 2 of Assumptions 1 and 2).

We impose (see for the detailed derivation Appendix A.3):

Assumption 1

$$\frac{11}{12} t > v > \frac{9}{8} t - \frac{5}{8} k,$$

and

Assumption 2

$$t > k > \frac{9}{5} t - \frac{8}{5} v.$$

In Assumption 1 and 2, $v = V - c^S - c^T$ represents the net social reservation price or the gains from the trade. Since in what follows we consider only very small deviations from our symmetric cost setting, we need not consider different $v_{ij}$.

3 Vertical integration in the trading industry

We start our analysis by first introducing our notion of vertical integration. We define vertical integration as a process that allows specific adjustments between the respective trading and settlement processes (e.g., establishing more efficient straight-through processing), and faster coordination in the vertically integrated organization as compared to arm’s length transactions. Vertical integration allows for specific investments between trading and settlement, most notably in the area of software and IT processes. In the absence of vertical integration, such specific investments might lead to severe hold-up problems between the two parties involved.

The specific investments tie together exchange A and CSD A. However, this closer link between the two comes at a cost: it makes the interaction of exchange A with CSD B and C as well as the interaction of CSD A with exchange B and C more costly, because it becomes more difficult for them to route trades of securities not listed on exchange A. Hence, vertical integration resembles a closed standard with basically a partially incomplete technology. The efficiency of the standard increases but the interaction with agents
outside the standard becomes more difficult (see, e.g., Shy (2001)). We depict this concept as follows: with the vertical integration of settlement and trading in A, trades on A are settled at lower costs in A \( (c^S_{AA} = c^S - y) \) but all cross-routings become more costly \( (c^S_{Aj} = c^S_{jA} = c^S + y) \). In both expressions \( y \) denotes the efficiency parameter associated with vertical integration. In Figure 2, we illustrate this entire process of vertical integration, which creates a more efficient link between settlement in A and trading in A but higher costs for the cross-links.

We analyze these changes in efficiency in the interaction between exchanges and settlement organizations. Settlement and trading prices in the vertically integrated organization are set separately by the exchanges and CSDs. We deliberately do not examine the benefit of vertical integration via a combined price-setting in our set-up. We do not take into account the internalization of the external effect of the pricing decision of the trading entity and the CSD, the double marginalization effect, as well as the possibility to use prices as a strategic factors against competitors. From our point of view this lacuna is justified by three arguments. First, because the implementation of an integrated decision process requires a proper transfer pricing system, which is often quite cumbersome. Second, because monopolists such as the CSDs usually attract the attention of regulators and are therefore not able to capture the profits associated with the strategic effects via the
price-setting mechanisms including foreclosure. Third, and most important, the effects of the internalization process are obvious and very well investigated (see, e.g., Tirole (1988)). The effects clearly favor vertical integration. Thus, by ignoring this effect we bias against vertical integration. We note that readers should keep this fact in mind when interpreting our results.

The sequence of moves comprises two stages. In the first stage, the CSDs simultaneously decide whether to vertically integrate with their respective exchange or stay unintegrated. In the second stage, given their integration decision CSDs and exchanges decide on their profit-maximizing prices and traders decide where to trade.

An alternative interpretation of our first stage, which also leads to the same results, is that only one CSD decides while facing competitors that are already integrated to a different extent. This interpretation reflects different historical preconditions compared to expectations driving potentially our results in the main analysis. We will come back to this alternative, sequential interpretation later.

In the following, we solve for subgame perfect Nash equilibria.

\[ t_1 \quad t_2 \]

CSDs decide upon vertical integration \hspace{1cm} CSDs and exchanges set prices

Figure 3: Timing of the game

### 3.1 Pricing decisions

We derive the profit-maximizing trading and settlement prices for exchanges and CSDs from Eqs. (8) and (9). Doing so gives us the subsequent reaction functions for \( i, j, l = \{A, B, C\} \) and \( i \neq j \neq l \neq i \):

\[
\begin{align*}
\frac{\partial p_i^T}{\partial p_{ji}^S} &< 0 \forall j \quad \text{and} \quad \frac{\partial p_{ij}^S}{\partial p_j^T} < 0 \forall j.
\end{align*}
\]

We note three different mechanisms in these reaction functions. First, prices of the corresponding up- or downstream activities are strategic substitutes (see Bulow, Geanakoplos, and Klemperer (1985)), i.e. \( \partial p_i^T / \partial p_{ji}^S < 0 \forall j \) and \( \partial p_{ij}^S / \partial p_j^T < 0 \forall j \). Hence, price increases by the settlement provider (for trades originated at either exchange) induce the exchanges
to lower their prices strategically. Second, the prices of the competitors on the trading level are strategic complements, i.e., $\frac{\partial p_T^i}{\partial p_T^j} > 0; i \neq j$. Increases in the prices of the competitor lead to increases in the prices of the other exchanges. This pattern shows the conventional feature of price competition with imperfect substitutes. Third, we note that because exchanges cannot price discriminate, they react strategically to settlement price changes even if their traders do not have to incur these settlement prices. We get $\frac{\partial p_T^i}{\partial p_S^ij} > 0$, for example, exchange A increases its price if CSDs increase their prices for settlements originated on exchange B or C. On the settlement level, the CSDs do not compete with each other at all but the prices set to the traders on the different exchanges do interact with each other. All these interactions are decisive in our analysis of the vertical integration process.

We solve the above system of prices simultaneously (see Appendix A.1 for details) and find for vertical integration of exchange and CSD A only (see Appendix A.1.1):

**Lemma 1** Vertical integration leads to a decrease in all trading prices. This effect is less pronounced in the integrated exchange A compared to the unintegrated exchanges B and C. With settlement, only the services provided via the direct, more efficient link become cheaper. All other settlement services become more expensive.

The somewhat surprising result of the effect of vertical integration on trading prices stems from the fact that direct trading and settlement prices are strategic substitutes (see Eq.(10)): higher settlement prices lead exchanges to reduce their trading prices. Hence, exchanges B and C, which face higher settlement prices for securities listed on A, have an incentive to reduce prices. Given that trading prices are strategic complements, this reduction triggers a decrease in A’s trading price. This effect is even reinforced by the increase in the other settlement prices that leads to a decrease in exchange A’s trading price as well.

A further channel through which vertical integration affects the payoffs of all agents is the impact of vertical integration on traders’ behavior and market coverage. Compared to non-integration, we find for integration of exchange and CSD A only (see Appendix A.2):

**Lemma 2**

(i) Market coverage of securities listed on all exchanges decrease.

(ii) The vertically integrated exchange A wins trades vis-a-vis exchanges B and C in securities listed on A while losing trades for securities listed on B and C.

The decreased coverage of the market noted in the first part of Lemma 2 results from an increase in the sum of trading and settlement prices, which traders located in the
backyard of B have to pay. The result of the second part of Lemma 2 is due to the fact that via vertical integration, cross-platform links become more costly, thereby making the respective home exchange more competitive.

3.2 Decisions to integrate vertically

We now turn to the analysis of the integration decisions. In order to reach an equilibrium, we analyze first the incentives of a single CSD to integrate vertically with its respective exchange given that the other CSDs are expected not to integrate. In a second step we address the incentives to vertically integrate if the other CSDs are expected to integrate vertically; either one or both of them. At last, we derive on the basis of the results of the first two steps the resulting equilibria of the vertical integration stage.

3.2.1 The stand-alone case

Given that CSD B and C stay unintegrated we use our findings on prices and quantities to derive the profit difference of the sum of profits in trading and settlement in A between integration and no integration. We define the resulting difference as $y \Delta \pi(0)$ (see Appendix A.5.2): 

$$
(\pi_T^{A} + \pi_S^{A}) - (\pi_T^{T} + \pi_S^{T}) = y \frac{198900k + 8476t - 173472v + 278409y}{608400t} \equiv y \Delta \pi(0).
$$

3.2.2 Vertical integration if other CSDs are expected to integrate

We examine first the incentives for CSD A to vertically integrate if only one of the other CSDs (say B) is also expected to do so. We derive the profit difference $\Delta \pi(1)$ as (see Appendix A.5.3):

$$
(\pi_T^{AB} + \pi_S^{AB}) - (\pi_T^{A} + \pi_S^{A}) = y \frac{36075k + 6097t - 17784v + 47160y}{152100t} \equiv y \Delta \pi(1).
$$

If both competing CSDs are expected to integrate, then we find as profit difference $\Delta \pi(2)$ (see Appendix A.5.4):

$$
(\pi_T^{ABC} + \pi_S^{ABC}) - (\pi_T^{A} + \pi_S^{A}) = y \frac{3588k + 1248v + 1612t + 4143y}{24336t} \equiv y \Delta \pi(2).
$$

We note that the parameter $v$ has an opposite effect in Eqs. (13) and (15). The negative impact of $v$ on $\Delta \pi(0)$ reflects the fact expressed in Lemma 2 that vertical integration leads to a decrease in market coverage. This profit-decreasing effect is most pronounced if the market coverage is large, i.e., if $v$ is large. In the step towards full integration (i.e., anticipating a B- and a C-silo), vertical integration only leads to lower costs, and hence, to lower prices. These lower prices allow the exchange to reach more traders in the backyard if $v$ is large, hence increasing the profit gains $\Delta \pi(2)$ of the vertically integrating CSD A.
We find (see Appendix A.6 for details):

**Lemma 3** $\Delta \pi(0) < \Delta \pi(1) < \Delta \pi(2) > 0$. *Vertical integration is more attractive the more other CSDs are expected to vertically integrate compared to a situation in which the other CSDs are expected to stay unintegrated.*

The explanation of Lemma 3 is that the integration of one CSD (say, B) implies that the costs for A that come from its own integration decrease. After the integration of B, A faces a competitor with an efficient link; thus making it more attractive to establish an efficient link on its own as well. After B’s integration, there is already an inefficient link between A and B, thereby eliminating these additional costs for A’s integration. Taking these two effects together makes A’s integration more attractive after B’s integration, compared to the situation in which A goes for a head start in vertically integrating. This effect is even more pronounced if not only B, but both B and C are already integrated.

### 3.2.3 The vertical integration equilibria

We use Lemma 3 to deduce the resulting equilibria of our integration decision stage. Because $\Delta \pi(2)$ is always positive, the in-between case with only two CSDs opting for vertical integration can never be an equilibrium. The same is true for a setting in which only one CSD decides for vertical integration, since doing so would require that $\Delta \pi(0) > 0$ and $\Delta \pi(1) < 0$, an obvious contradiction to Lemma 3 above. Because of our symmetric setting, only two equilibrium candidates remain: either all CSDs stay unintegrated or all of them integrate vertically. Although integration of all CSDs always constitutes an equilibrium in the integration-decision stage (since $\Delta \pi(2) > 0$), non-integration is only an equilibrium if $\Delta \pi(0) < 0$. The remaining question is whether this equilibrium is indeed feasible. Figure 4 addresses this question.

Figure 4 displays Eq. (13) and Assumptions 1 and 2 on the parameters (the grey area is not compatible with these assumptions), in $\frac{h}{t} - \frac{v}{t}$ space. The figure shows that vertical integration can indeed pay off. The white range in the figure displays the parameter combinations that are not only feasible, but that also increases the sum of profits of A with vertical integration even if the marginal efficiency effect is evaluated at $y = 0$, i.e., $\Delta \pi(0) > 0$. In the black region, integration does not pay off.

However, it turns out, that our full integration equilibrium might lead to lower payoffs for all CSDs, i.e., we are either facing a prisoner’s dilemma outcome in a setting in which the full integration equilibrium is unique, or a potential coordination problem with two equilibria. In both cases, CSDs may end up being fully integrated but with lower profits compared to the non-integration case.

These problems become obvious when we derive the difference in profits between a situation in which no CSD is integrated to a situation in which all CSDs are integrated.
Figure 4: Effect of vertical integration on profit of A

(see Appendix A.5.4):

\[
\left( \pi_i^{T,ABC} + \pi_i^{S,ABC} \right) - \left( \pi_i^T + \pi_i^S \right) = y \frac{75k + t - 72v + 111y}{225t} \equiv y \Gamma \quad i = A, B, C. \quad (16)
\]

In Appendix A.7 we show that the parameter set for which \( \Delta \pi(0) < 0 \) holds is a subset of parameter set for which \( \Gamma < 0 \) prevails, i.e., whenever \( \Delta \pi(0) < 0 \) we get \( \Gamma < 0 \).

Given the results, we can state:

**Proposition 1**

- In equilibrium either all CSDs decide to integrate, or none of them does so. Full integration is always an equilibrium, but non-integration only constitutes an equilibrium if and only if \( \Delta \pi(0) < 0 \).

- Hence, we find three potential settings depending on parameter setting

1. With \( \Delta \pi(0) > 0 \) and \( \Gamma > 0 \) full integration is the only equilibrium. CSDs’ profits increase with integration.
2. With \( \Delta \pi(0) > 0 \) and \( \Gamma < 0 \) full integration is the only equilibrium. CSDs’ profits decrease with integration (prisoner’s dilemma case).
3. With \( \Delta \pi(0 < 0 \) (and hence \( \Gamma < 0 \)) full integration as well as non-integration are both equilibria. CSDs’ profits decrease with integration (coordination problem case).
Figure 5 illustrates the different equilibria settings. Above the black area $\Delta \pi(0) > 0$, and below the white one $\Gamma < 0$ prevails. Hence, in the white area case 1 prevails. In the grey area we end up with case 2, the prisoner’s dilemma. In the black area case 3 with a multiplicity of equilibria emerges with the possibility of a coordination failure leading to the bad full integration equilibrium.

Cases 2 and 3 result from pronounced negative externalities that lead to the possibility that individual actions produce outcomes that lower the profits of all players involved. Case 3 becomes most likely if either exchange has a large backyard. Pronounced gains from trade, i.e., large $v$, imply that an overproportional part of trades take place via the inefficient link, making unilateral deviation from the non-integration setting not attractive. This case is especially true if the securities listed on the different exchanges are imperfect substitutes, making them attractive for foreign traders, e.g., for diversification purposes.

If we interpret our setting in a sequential manner, in which one after the other CSD decides, then history matters. Given that history matters with case 3, initial starting points matter, making it difficult to make a clear-cut prediction, independent of the starting point. This result has an important implication for the organization structure among European countries. Since the financial securities industry was originally organized along national lines, exchanges and CSDs in the individual countries have often integrated their systems. Hence, with the creation of a single European market, because of the coordination problem the industry may be stuck with vertical integration, even though separation would be more profitable.

Figure 5: Effect of vertical integration of all financial securities service provider on profits
What the CSDs see as a potentially excessive degree of vertical integration happens because vertical integration comes with negative externalities imposed on the other CSDs and exchanges. We outline this mechanism in more detail below.

### 3.3 Comparative statics

From our analysis so far we know that the decisive factor in whether non-integration may result in equilibrium is that \( \Delta \pi(0) < 0 \). Using Eq. (13), we compute comparative static effects.

We find:

**Proposition 2**  
Full vertical integration is more likely to be the only equilibrium if

- demand for liquidity is high \( \partial(\Delta \pi(0))/\partial k > 0 \), and
- the gains from trade are low \( \partial(\Delta \pi(0))/\partial v < 0 \).

- The effect of more integrated financial markets is ambiguous: if the liquidity effect \( k \) is relatively large compared to \( v \), then a higher degree of integration increases the profitability of vertical integration and vice versa for a relatively small \( k \) and \( y \).

The thinking behind these findings is that the more liquidity matters, the higher is the share of trades on exchange A of securities kept safe in CSD A using the efficient link. Hence, the cost advantage of vertical integration is most pronounced.

Higher gains from trade (larger \( v \)) lead to more trades on exchange B of securities kept safe in A and vice versa. These trades are settled through the inefficient link after vertical integration. Thus, since these trades increase in absolute and relative terms with higher gains from trade, higher gains from trade make vertical integration less attractive.

The effect of less integrated financial markets (higher \( t \)) is ambiguous and depends on \( k \) and \( v \). If the liquidity effect \( k \) is relatively large compared to the gains from trade, then a higher \( t \) decreases the profitability of vertical integration \( \partial(\Delta \pi(0))/\partial t > 0 \) and vice versa. The thinking behind this mechanism is that the demand via the inefficient links, either from the integrated CSD A to unintegrated exchange B/C or from exchange A to CSD B/C, increases in \( v \) because more trades are initiated from the backyard. The contrary is true for \( k \), since fewer trades are initiated on the home market. In contrast, the demand via the efficient link is independent of \( v \) but increases in \( k \). An increasing \( t \) reduces the influence of both \( k \) and \( v \). Therefore, if \( k \) is relatively large compared to \( v \), an increasing \( t \) increases the demand via the inefficient links because it protects exchanges from the liquidity disadvantage. The demand via the inefficient link decreases in \( t \) if \( k \) is relatively small because then the loss of traders in the backyards dominates. In contrast, the demand via the efficient link always decreases in \( t \). Summing up these effects, relatively
more trades are processed over the inefficient link and the gains of integration decrease while the differentiation increases if \( k \) is relatively large.

### 3.4 Welfare consequences of vertical integration

Next, we investigate the welfare consequences of vertical integration. We do so by comparing welfare in the non-integration case with that in the integration case. We thereby employ a broad welfare measure embracing surplus of all traders (TS) plus the profits of all exchanges and CSDs. In equation (17), we express the welfare effect (see Appendix A.5.4):

\[
(TS_{ABC} - TS) + 3[(\pi^T_{ABC} + \pi^S_{ABC}) - (\pi^T + \pi^S)] = y \frac{225k + 11t - 192v + 321y}{150t} \equiv y \Delta W.
\]

To determine whether private incentives towards vertical integration accord with the social motivations to achieve full integration, we compare Eqs. (13) and (17). Comparing these two expressions shows that, compared to \( \Delta \pi(0) \), welfare increases for a larger set of parameters (see Appendix A.8). For a parameter region vertical integration is advantageous for society even if it is the pareto-dominated equilibrium from the viewpoint of the exchanges.

We get:

**Proposition 3**

1. With \( \Delta \pi(0) > 0 \), decentralized decision making leads to the welfare optimal full integration solution.

2. With \( \Delta \pi(0) < 0 \), we can distinguish two subcases:

   (a) With \( \Delta W > 0 \), due to the coordination problem, decentralized decision making either leads to welfare optimal full integration or to too little vertical integration.

   (b) With \( \Delta W < 0 \), there is potentially too much vertical integration.

There are two facts that explain why with \( \Delta \pi(0) < 0 \) decentralized decision making of CSDs may lead potentially to suboptimal decisions. On the one hand, integrating unilaterally leads to negative externalities on other CSDs and exchanges. Too much vertical integration might prevail. On the other hand, vertical integration leads to positive external effects for consumers. This is revealed by computing the differences in trader surplus between the full integration and the non-integration case (see Appendix A.5.4):

\[
\Delta TS = y \frac{25k + 3t - 16v + 33y}{50t}.
\]

Since these external effects are not taken into account by individual CSDs, too little vertical integration might occur.
4 Horizontal integration

Given network economies as well as economies of scale and scope, horizontal integration is an alternative to vertical integration that is intensively and hotly discussed in the financial press (see, e.g., Economist (2008)). Therefore, we compare horizontal integration with vertical integration.

We consider horizontal integration only at the settlement level. At this level, horizontal integration leaves the market structure unchanged, and the settlement providers stay in their monopolistic position. Such a situation is comparable to the industry organization in the U.S. with very few actors on the settlement level. In our framework, the horizontal integration of exchanges for exploiting liquidity and network effects leads to a joint exchange that eliminates the limited access of certain traders to certain stocks, and thus also removes the coverage gap in our base model. Since the horizontal integration of exchanges changes the market structure at the trading level, it also changes the entire model structure, which makes a comparison with vertical integration infeasible. Hence, we consider the case in which CSDs decide on horizontal integration.

To capture the concept of network effects and of economies of scope at the clearing and settlement level, we model horizontal integration as cost savings of all settlement providers denoted by $b \cdot y$ ($b > 0$). So, while exchanges’ costs amount to $c^T$, the costs of all settlement provider are $c^S - by$. Given that the monopolistic settlement providers all experience identical cost savings, their profits always increase. Since there are only gains and no costs to horizontal integration, this dominance over the non-integration case is straightforward. Nonetheless, it is not clear whether this dominance is true for the comparison with vertical integration which offers higher cost savings for the efficient link but cost-increases for the inefficient ones.

We introduce the decision about horizontal integration as a stage that occurs before the vertical integration decision. In this earlier stage CSDs decide about the integration of all CSDs. If they decline to integrate horizontally, they may choose simultaneously to integrate vertically in the following stage and then compete in prices. If there is horizontal integration, then the price-setting stage follows directly.

![Figure 6: Timing of the game](image-url)
4.1 The integration equilibria

The CSDs choose horizontal integration whenever it is individually (and because of symmetry, jointly) profitable for them to do so. Hence, CSDs decide to integrate horizontally whenever the payoff is larger than the equilibrium payoff of the second stage subgame, which is either non-integration or full vertical integration.

By plugging the profit-maximizing prices together with the demand functions in the profit functions, we can derive the profit difference of horizontal integration compared to non-integration for all settlement providers. This profit difference shows the sum of settlement providers’ profits after horizontal integration minus the one before integration (see Appendix A.9):

$$
\Delta(\pi_A^s + \pi_B^s + \pi_C^s) = 8by \frac{2t + 6v + 3by}{75t} > 0.
$$

(19)

Horizontal integration decreases the costs and is therefore always profitable compared to non-integration. The profit difference, which is decisive when we compare horizontal with vertical integration, becomes even larger whenever the gains from trade are larger because it increases the market size. The same is true for more integrated financial markets. More integrated financial markets (smaller $t$) imply a larger reach of each security in foreign markets and hence a larger market size that can be exploited at lower costs.

CSDs will opt for horizontal integration whenever non-integration is an equilibrium in the second stage, i.e., $\Delta \pi(0) < 0$ (and hence $\Gamma < 0$). In that case, the non-integration equilibrium is pareto-dominant to the full vertical integration equilibrium. Given our above findings, horizontal integration always dominates full vertical integration in that parameter region. This finding implies that the availability of horizontal integration overcomes the coordination problem of the vertical integration case.

Furthermore, horizontal integration is also the equilibrium for the parameter region of the prisoners’ dilemma, i.e., $\Delta \pi(0) > 0$ and $\Gamma < 0$, because the profits are lower with full integration than with non-integration. CSDs anticipate this problem of the second stage game and therefore coordinate on horizontal integration.

At last, for $\Delta \pi(0) > 0$ and $\Gamma > 0$, vertical integration is still the only equilibrium in the following subgame and pareto-dominates non-integration. Hence, the equilibrium of the whole game depends on the size of the cost savings parameter $b$.

Substracting Eq. (19) from the threefold of (16) yields:

$$
\Sigma_{\text{Profits}} = y \frac{75k + t - 72v + 111y - 8b(2t + 6v + 3by)}{75t}.
$$

(20)

We interpret this expression as the incentives for CSDs to choose horizontal rather than vertical integration.
We check the sign of Eq. (20) and solve for the critical $b$. Doing so just leads to indifference between vertical and horizontal integration and yields (at $y = 0$):

$$b^* = \frac{75k + t - 72v}{16(t + 3v)}. \quad (21)$$

Hence, $b^*$ is always smaller than one. With $b = 1$, the integrated CSD faces efficient links to all exchanges with horizontal integration. With vertical integration, the integrating CSD must trade off the direct efficient link for the indirect inefficient link. The cost disadvantage of the inefficient link outweighs the competitive advantage that the other settlement providers’ competitive advantage and deters them from relying on the inefficient links as well. Thus, horizontal integration dominates vertical integration for $b = 1$.

The direct following for the equilibrium decision on horizontal integration is that CSDs decide to integrate horizontally whenever the actual $b$ is larger than $b^*$, and vice versa.

We summarize our findings in Proposition 4.

**Proposition 4**

- In equilibrium, CSDs will decide either to fully integrate vertically or horizontally.
- Hence, we find three potential equilibria depending on parameter setting:
  1. With $\Gamma < 0$ CSDs choose to integrate horizontally, thereby solving the prisoner’s dilemma and coordination problem.
  2. With $\Gamma > 0$ and $b > b^*$, CSDs choose to integrate horizontally.
  3. With $\Gamma > 0$ and $b < b^*$, CSDs choose to integrate vertically.

This result sheds new light on the TARGET2-Securities initiative. The objective of the Eurosystem’s TARGET2-Securities initiative is to establish an IT platform that offers centralized settlement services. By connecting all involved CSDs, the main aim is to reduce the barriers and costs of cross-border trades.

In our model, TARGET2-Securities fit the horizontal integration case. All systems become compatible to each other, and thus economies of scale and scope decrease the costs of settling trades. In a “Memorandum of Understanding” (TARGET2-Securities (2009)) all major European CSDs confirmed their intention to use TARGET2-Securities once it is in operation. Hence, the initiative may be seen as a mechanism for CSDs to coordinate on horizontal integration. Even though it was introduced by the Eurosystem, the CSDs have taken up the initiative in order to avoid adverse competitive effects of their organization structures. Therefore, our analysis shows that not only the regulator may have an incentive to lower the costs of cross-border trades via horizontal integration but that it may be in the interest of the CSDs as well.
4.2 Comparative statics

By using horizontal integration CSDs can overcome the prisoner’s dilemma and the coordination problem that might occur with vertical integration. The integration decision crucially depends on the cost savings parameter $b$. The comparative statics of $b^*$ are in line with the ones on $\Delta \pi(0)$ and we can summarize:

**Proposition 5** Vertical integration becomes more attractive for CSDs relative to horizontal integration if

- the liquidity effect is more pronounced (larger $k$),
- and the gains from trade become smaller (smaller $v$).
- The effect of more closely integrated financial markets (larger $t$) is ambiguous. The attractiveness of vertical integration increases in $t$ whenever $v > k$, and vice versa.

The thinking here is rather similar to that in Proposition 2. With vertical integration, a more pronounced liquidity effect shifts more trades into the efficient link. This shift has a positive effect on the profits of the integrated CSD, making vertical integration relative to horizontal integration more attractive. In contrast, with horizontal integration, all settlement links become cheaper to the same extent. Hence, a change in the market shares of the different exchanges does not affect profits in the case of horizontal integration and leaves no room for an effect of $k$ on the incentive to horizontally integrate.

Gains from trade imply that relatively more trades are settled via the inefficient links making vertical integration less and at the same time horizontal integration more attractive.

The effect of the financial market integration parameter $t$ is ambiguous. A lower degree of integration (larger $t$) decreases the profitability of horizontal integration, because fewer additional trader are captured. In contrast, Proposition 2 shows, that if $k$ is relatively large, then an increasing $t$ decreases the profitability of vertical integration. In sum, we still have the ambiguity.

4.3 Welfare comparison

Here, we evaluate from a welfare perspective the different industry equilibria in either full horizontal or vertical integration. We examine whether there is a potential coordination effect, asking if it is socially feasible to have fullvertical integration when private incentives stand in the way such that initial horizontal integration is preferred or vice-versa.

Since we have already investigated the private incentives to reach either of the two industry equilibria in Proposition 4, we evaluate full vertical integration and horizontal integration from a welfare point of view. Computing the relative gains in welfare accruing
from full vertical integration (see Eq. (17)) compared to horizontal integration gives us (see Appendix A.9):

$$\Sigma_{\text{Welfare}} = \frac{225k + 11t - 192v + 321y - 32b(2t + 6v + 3by)}{150t}.$$  (22)

Evaluated at $y = 0$ this expression yields the critical social $b_s^*$ at which society is just indifferent between full horizontal and full vertical integration.

$$b_s^* = \frac{225k + 11t - 192v}{64(t + 3v)}.$$  (23)

Next, we compare the private incentives for reaching either equilibrium with the relative advantages of either equilibrium from a social point of view. When we compare $b^*$ with $b_s^*$ we find

$$\text{sign} \ (b^* - b_s^*) = \text{sign} \ \left( \frac{75k - 7t - 96v}{64(t + 3v)} \right).$$  (24)

Figure 7 illustrates this difference and distinguishes between the two cases in which these differences are positive (upper part) or negative (lower part).

Hence, we find:

**Proposition 6**  Social compared to private perspective: With strong (weak) liquidity effects and weak (strong) social net reservation prices, the industry might end up in a bad equilibrium in which settlement providers are vertically (horizontally) integrated.

To better explain the economic reasoning behind this result, we note that both vertical and horizontal integration impose a positive externality on traders. The externality of
vertical integration increases with the relative importance of liquidity compared to the gains from trade. More importantly, the impact of $k(v)$ is more pronounced on traders via the externality than it is on the profit difference of the CSDs. In contrast, the externality of horizontal integration is independent of the importance of liquidity, but is positively influenced by the gains from trade. This positive influence increases disproportionate to the influence on the profit difference of the CSDs. Thus, the attractiveness of vertical integration increases more strongly in the relative importance of liquidity from a private perspective compared to the social point of view. The privately demanded cost savings for horizontal integration are larger than the socially demanded.

5 Testable hypotheses

In this section we first extend our model by endogenizing listing decisions. Second, we use our analysis to discuss a number of key developments in the financial securities service industry. In both steps, we summarize our discussion by deriving a number of testable hypothesis emerging from our analysis.

5.1 Endogenous listings

Up to now we have performed our analysis against the background of a given distribution of listings of securities across the exchanges. Here, we extend the model by endogenizing the listings of securities. Doing so, enables us to derive an empirically testable hypothesis on the relation between listing fees and the organizational structure of the financial securities service provider.

We describe the listing decision as a two-stage decision. In stage 1, exchanges set listing fees and firms decide about their listing venue. In stage 2, exchanges and CSDs set their trading and settlement fees and traders decide if and where to trade. To analyze this two-stage decision, we use an objective function that governs the listing decision. There are two obvious factors that determine the listing decision. First, the costs of the listing consisting of direct ones (paid to the exchange) and indirect ones (costs of reporting and disclosing information and the like). The second factor, which is potentially of greater importance for the listing decision, is the degree of access to capital markets. This latter effect is strongly affected by the size (in our model market coverage) and liquidity of the respective exchange. Firms that are setting up a listing are especially interested in reaching a wide range of potential investors for their securities. This range provides them with immediate investors in the primary market and a broader subsequent market, making the initial investment more attractive. Hence, initial investors are willing to pay higher prices, which leads to a lower degree of underpricing. Furthermore, a broader set of investors
facilitates subsequent (seasoned) offerings.

Therefore, we can state the objective as:

\[ \Pi_f = a \times \text{coverage} - p^T_L - p^S_L - l_f. \]  \hspace{2cm} (25)

In equation (25) coverage denotes the market reach of the security, and \( p^T_L \) is the price to be paid to the exchange and CSD. Parameter \( a \) stands for the importance of the coverage and \( l_f \) is a differentiation parameter of a firm \( f \). We believe that such a differentiation is relevant, since it is rare for firms to choose a primary listing abroad (at least for firms in developed countries). The parameter \( l_f \) corresponds to \( t \) of the former sections and therefore decreases also with more integrated financial markets.

Backward induction indicates two results. First, that listings are very important for exchanges and CSDs, since they are absolutely necessary for CSD business and because they offer a competitive advantage via the liquidity effect for exchanges. This effect should lead to an incentive for the exchange to “buy in” this market side and result in rather “low” listing fees, a standard result from the literature on two-sided markets (see, e.g., Armstrong (2006)).

Second, firms anticipate their market coverage on the respective trading venue. Since vertical integration affects the market coverage negatively, an integrated exchange has to reduce \( p^T_L \) in order to avoid loosing listed securities. This incentive for vertically integrated exchanges to compete with low listing fees is enforced the higher the importance of coverage and the higher the degree of financial market integration from the view of the firms, i.e., the lower \( l_f \).

We summarize this in

**Hypothesis 1**

1. *To counter their smaller market coverage we expect vertically integrated exchanges to compete more fiercely in listing fees.*

2. *The more important market coverage becomes and the higher the perceived degree of financial market integration, the stronger this effect becomes.*

Table 1 gives a rough indication that our Hypothesis 1 holds true. In the table we compare the listing and admission fees of Deutsche Boerse as the European exchange with the highest, and the LSE as the one with the lowest, degree of vertical integration. The fact that listing and admission fees are lower on Deutsche Boerse points in the direction of our above hypothesis.

### 5.2 Over-the-counter (OTC) trading

The alternative to trading on exchanges is bilateral OTC trading. In OTC transactions traders privately negotiate the individual conditions of a trade. OTC trades are either
standardized or non-standardized contracts. With non-standardized contracts, trading partners can tailor the terms and conditions to their needs. Strictly speaking, such contracts are a private contract and therefore do not have necessarily a need to be settled on a centralized platform. In contrast, standardized contracts involve recurring terms and conditions, e.g., a contract that defines the transaction of specific shares. Such contracts usually need settlement. In the following, we focus only on OTC trading of standardized contracts that needs settlement services as the other transactions do not influence the integration decision.

OTC trading of standardized contracts influences the integration decision of traditional exchanges via two potential mechanisms. First, we assume that OTC trading is not a substitute for trading on exchanges. To settle OTC trades, traders also need a link to the corresponding CSD. If it is a vertically integrated CSD, then such a link is outside of the vertical system and thus is “inefficient”. Therefore, for larger OTC markets, more trades are settled via the inefficient link. If demand elasticity is finite, then the integrated CSD is not able to fully transfer the increased costs to traders, which implies a reduction in the CSD’s profit. Hence, the larger the OTC market, the less attractive is vertical integration for the exchanges. Vertical integration is also less appealing for the welfare of the society, since society as a whole must carry the additional costs.

Recent efforts as the Dodd-Frank-act in the U.S. and the European Market Infrastructure Regulation (EMIR) in the EU attempt to regulate the OTC market by bringing OTC trading to exchanges and by implementing a mandatory central clearing for OTC derivatives. The first aspect of these regulatory initiatives does not influence our analysis, since more trading on the market increases the number of securities traded and the additional trading has no effect on the incentives to integrate. In contrast, the second objective may lead to a greater standardization of those transactions that need settlement services. As this greater standardization corresponds to a larger market that needs settlement via an inefficient link, the incentives for vertical integration decrease.

A second effect arises if we consider the possibility that OTC trading is a substitute for exchange trading. Through vertical integration the cost of OTC trading could be raised, so vertical integration can be a mechanism for a silo’s competitive advantage. Thus,

<table>
<thead>
<tr>
<th></th>
<th>Deutsche Boerse</th>
<th>London Stock Exchange</th>
</tr>
</thead>
<tbody>
<tr>
<td>Admission fees</td>
<td>750 - 5,500 €</td>
<td>10,453 - 200,000 €</td>
</tr>
<tr>
<td>Listing fees</td>
<td>5,000 - 10,000 €</td>
<td>4,900 - 48,300 €</td>
</tr>
</tbody>
</table>

Table 1: Admission and listing fees for ordinary shares depending on market segment and market capitalization (Source: Kaserer and Schiereck (2011))
for a given size of the OTC market, a higher degree of substitutability of the trading services between exchanges and OTC trading implies that vertical integration becomes more advantageous.

Hypothesis 2

1. With a larger standardized OTC market for which clearing takes place via CSDs we should expect a lower level of vertical integration and vice versa.

2. For a given size of the OTC market, a higher degree of substitution between trading on exchanges and OTC trading should lead to more vertical integration.

5.3 Multilateral trading facilities

Recently, a large number of Multilateral Trading Facilities (MTFs) have emerged. These MTFs offer trading services in various ways, but do not offer listing services.

We interpret the emergence of MTFs as being similar to OTC trading. MTFs are an additional alternative for trading that also needs a link to the CSDs, an inefficient one in the case of an integrated CSD.

Trading on MTFs comes from three sources. First, MTFs generate new trading activity, e.g., through faster systems. Second, MTFs bring previous bilateral OTC trading to more efficient centralized platforms. Third, MTFs substitute trading activity from traditional exchanges. The first and third source lead definitively to shifting settlements from the efficient to the inefficient links, making vertical integration less attractive. The second effect is neutral if previous OTC trades are perfectly substituted by MTFs leading to settlement via the inefficient link, too. Hence, the existence of MTFs and growth in their market share lead to lower incentive to integrate vertically.

If, however, a vertically integrated silo already exists, it faces a better competitive situation relative to MTFs as compared to stand-alone exchanges. This is due to the fact that the vertically integrated silo has a better cost structure relative to MTF initiated trades which are settled via the inefficient link. Hence, we should expect that the integrated silo should lose less market share to MTFs as compared to stand-alone exchange.

Hypothesis 3

1. The existence of MTFs and their growth should let us expect that less vertically integrated financial securities service provider emerge.

2. For existing vertically integrated silos we should expect that they lose less market share to MTFs compared to stand-alone exchanges.

We find some first empirical support for the second part of our hypothesis. In Table 2, the market shares show that Deutsche Boerse, which is the more vertically integrated exchange, lost fewer market shares to new MTFs compared to the London Stock Exchange.
Table 2: Market share of MTFs (BATS, Chi-X, Nasdaq OMX Europe MTF, and Turquoise) in DAX 30 and FTSE 100 shares in 2009. (Source: BATS Europe website)

<table>
<thead>
<tr>
<th>Market share of MTFs</th>
<th>DAX 30</th>
<th>FTSE 100</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>23 percent</td>
<td>32 percent</td>
</tr>
</tbody>
</table>

5.4 Algorithmic trading and new pricing schemes

Algorithmic trading (AT) has increased greatly in the recent past. AT is typically defined as the automatic trading of financial assets on the basis of computer algorithms. Behind this broad definition, there exists a wide variety of different algorithmic patterns, such as algorithms based on statistical arbitrage or splitting large orders into small ones. Because AT is both a supplier of liquidity and a demander of liquidity, the net effect is a priori not clear. In a recent study, Hendershott, Jones, and Menkveld (2011) provide clear empirical evidence for a positive causal effect for AT on liquidity. They find that for large stocks in particular, AT reduces spreads and therefore also benefits other non-AT traders.

Because AT is present on many trading platforms, we interpret the evolvement of AT as a reduction of the liquidity advantage of the home market, i.e., a reduction of $k$. This reduction makes vertical integration less appealing. With a lower $k$ fewer trades take place via the efficient links and more by inefficient links. Given that AT is most prevalent in large stocks, vertical integration is least attractive for exchanges that specialized in trading large cap stocks.

A similar mechanism that leads to a reduction of the home market’s liquidity advantage of the home market comes from new pricing schemes of MTFs, through which MTFs try to overcome the liquidity advantage of the established exchanges. To be able to compete with the traditional exchanges, MTFs have been very innovative in bypassing the expectation or liquidity advantage of the exchanges. The MTFs try to coordinate major players in the market on their platform or to introduce new pricing schemes such as Maker-Taker pricing. Maker-Taker pricing schemes pay for every limit order (e.g., an order that is contingent on a specific price, which therefore “makes” liquidity) and bill for every market order (e.g., an order to buy/sell at the best available price, which therefore “takes” liquidity). In sum, these pricing schemes also lead to a reduction of $k$ making vertical integration less attractive.

Hypothesis 4

1. With an increase in the share of algo trading which reduces the liquidity advantage of home markets we should observe less vertical integration.

2. Since algo trading is most pronounced in large caps, exchanges which are specialized
in large-cap trading are less likely to form part of a silo.

3. We should also observe less vertical integration where new pricing schemes, such as Maker-Taker pricing, is widespread.

6 Conclusion

We consider that our main contribution in this paper is that we clarify the relation between the choice of organizational design and competition in the financial securities service industry. To do so, we develop a stylized model of the financial securities service industry in which competing differentiated exchanges, i.e., the upstream producers, build on the services of the monopolistic central securities providers, i.e., the downstream producers. Every exchange is linked to a downstream provider in the way that the listed securities are kept safe in the respective CSD. The liquidity effect delineates a key advantage of the “home” exchange which states traders’ preferences for liquidity on a single exchange. The liquidity effect, the degree of differentiation among exchanges, and the social net reservation price are the key drivers in our model. In this framework, vertical integration establishes a closed technological standard that allows for specific linkages between up- and downstream producers.

We show that for a pronounced liquidity effect and/or relatively low gains from trade, private actors decide to vertically integrate in equilibrium. However, it turns out that for an intermediate range of the gains from trade and the liquidity effect, profits of exchanges and CSDs are lower compared to non-integration. Horizontal integration acts as a coordination mechanism to avoid this problem. Further, horizontal integration dominates vertical integration the less pronounced the liquidity effect.

Our analysis makes it possible for us to derive several key empirical predictions. These predictions relate to recent industry trends and regulatory changes on the organizational structure in the financial securities service industry. Our analysis does not reveal a clear-cut picture. Instead, different industry trends and regulatory changes point into different directions. Although, given the background of our analysis, the emergence of multilateral trading facilities and the growth of algorithmic trading implies lower incentives to vertically integrate, the regulatory pressures to push OTC trading onto regular exchanges favors vertical integration. Financial market integration, in contrast, has an ambiguous effect on organizational design in the financial securities service industry.

Finally, we note two potential caveats of our analysis. First, we focus on what we consider to be the major mechanisms of vertical integration, namely to decrease (increase) costs of vertical transactions inside (outside) the silo. Thereby, we left the potential gains from avoiding double marginalization with vertical integration aside. This effect speaks in
favor of vertical integration and changes the level at which vertical integration is favorable. However, it does not affect our comparative statics, so we consider this exclusion to be a rather minor limitation. What may be a more important issue is the fact that we concentrate on symmetric exchanges that are not specialized at all, an assumption that is at odds with many exchanges. An in-depth analysis of this kind of asymmetry might be an interesting route for future research.
References


A Appendix

A.1 Proof of Lemma 1

We solve the system of price reaction functions (see Eqs. (10)-(12)) to derive the second stage equilibrium prices as:

\[
\begin{align*}
\pi^T &= \frac{4}{5}c^T - \frac{1}{13}c^S + \frac{2}{65}(c^S_i + c^S_d) - \frac{8}{65}(c^S_i - c^S_d) + \frac{1}{26}(c^S_j + c^S_l) - \frac{1}{130}(c^S_j + c^S_l) + \frac{1}{5}V + \frac{1}{15}t \\
\pi^S &= \frac{7}{13}c^S_i - \frac{1}{65}(c^S_j + c^S_l) + \frac{4}{65}(c^S_j - c^S_l) - \frac{1}{52}(c^S_j + c^S_l) + \frac{1}{260}(c^S_j + c^S_l) - \frac{2}{5}c^T + \frac{2}{5}V + \frac{3}{10}t + \frac{1}{2}k \\
\pi^{ij} &= \frac{73}{130}c^S_i - \frac{1}{65}(c^S_j + c^S_l) + \frac{1}{26}(c^S_j - c^S_l) - \frac{1}{52}(c^S_j + c^S_l) + \frac{4}{65}(c^S_j + c^S_l) - \frac{2}{5}c^T + \frac{2}{5}V + \frac{2}{15}t
\end{align*}
\]

(A.1)  
(A.2)  
(A.3)

By plugging in the respective prices we receive the prices for the different scenarios, prices with non-integration, integration of A only, integration of A and B and integration of all CSDs.

A.1.1 Non-integration

\[
\begin{align*}
\pi^T &= \frac{1}{5}V - \frac{1}{5}c^S + \frac{4}{5}c^T + \frac{1}{15}t \\
\pi^S &= \frac{2}{5}V + \frac{3}{5}c^S - \frac{2}{5}c^T + \frac{3}{10}t + \frac{1}{2}k \\
\pi^{ij} &= \frac{2}{5}V + \frac{3}{5}c^S - \frac{2}{5}c^T + \frac{2}{15}t
\end{align*}
\]

A.1.2 Vertical integration of A only (indicated by superscript A)

<table>
<thead>
<tr>
<th></th>
<th>A</th>
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</tr>
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<td>(p^S_i)</td>
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### A.1.3 Vertical integration of A and B (indicated by superscript AB)

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### A.1.4 Vertical integration of all CSDs (indicated by superscript ABC)

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</table>

These prices allow us to state Lemma 1.
A.2 Proof of Lemma 2

By plugging the optimal prices from Eqs. (A.1)-(A.3) into the demand functions we receive the second stage equilibrium demand:

\[
d^i_i = \frac{156k + 52t - 138c_i^S + 63(c_{ij}^S + c_{ti}^S) + 21(c_{ij}^S + c_{ti}^S) - 9(c_{ij}^S + c_{ti}^S) - 6(c_{ij}^S + c_{ti}^S)}{312t}
\]

\[
d^i_i = \frac{208V - 130k + 26t - 208e^T - 338c_{ij}^S - 28c_{ij}^S + 105c_{ij}^S + 35c_{ij}^S - 10c_{ij}^S + 47c_{ij}^S + 7c_{ij}^S - 13(c_{ij}^S + c_{ti}^S)}{520t}
\]

\[
\sum d^i_n = \frac{624V + 208t - 624e^T - 30c_{ij}^S - 339(c_{ij}^S + c_{ti}^S) - 9(c_{ij}^S + c_{ti}^S) + 15(c_{ij}^S + c_{ti}^S) + 36(c_{ij}^S + c_{ti}^S)}{780t}
\]

In the following, we distinguish again the 4 cases.

A.2.1 Non-integration

\[
d^i_i = \frac{3k + t}{6t}
\]

\[
d^i_i = \frac{8v - 5k + t}{20t}
\]

\[
\sum d^i_n = \frac{4(3v + t)}{15t}
\]

A.2.2 Vertical integration of A only

<table>
<thead>
<tr>
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<th>B</th>
<th>C</th>
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A.2.3 Vertical integration of A and B
A.2.4 Vertical integration of all CSDs

<table>
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</table>

These quantities allow us to state Lemma 2.

A.3 Derivation of assumptions

For our setup to hold we need to impose 3 assumptions:

1. In order to receive an open backyard the marginal traders in the backyard of the foreign exchange are not allowed to overlap, i.e., \(x_4^A < x_4^A\).

\[
\frac{2(3v + t)}{15t} < \frac{-6v + 13t}{15t} \Rightarrow v < \frac{11}{12}t \quad (A.7)
\]

2. The marginal traders between exchanges A and B (or C) need to be located at a positions smaller than \(\frac{1}{3}\), i.e., \(x_1^A < \frac{1}{3}\).

\[
\frac{3k + t}{12t} < \frac{1}{3} \Rightarrow k < \frac{1}{3} \quad (A.8)
\]

3. As usual in Salop-models the surplus generated by a trade needs to be positive. As this condition is obviously fulfilled for the marginal traders in the backyard, the value of trade or liquidity effect has to be sufficiently large to fulfill this condition for the marginal trader between the exchanges.

\[
V - p_T^A - p_S^{AA} + k - t * x_1^A = \frac{8v + 5k - 9t}{20} > 0
\]

\[
k > \frac{9}{5}t - \frac{8}{5}v
\]

\[
v > \frac{9}{8}t - \frac{5}{8}k \quad (A.9)
\]

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A.4 Computation of the trader surplus and welfare

\[
TS = \sum_i \int_0^{x_i} (V - p_i^T - p_i^S + k - tx)dx + \int_{x_i}^{x_i^3} (V - p_i^T - p_i^S - t(1/3 - x))dx + \int_{x_i^3}^{1/3} (V - p_j^T - p_i^S - t(x - 1/3))dx + \int_{x_i}^{2/3} (V - p_i^T - p_i^S - t(2/3 - x))dx + \int_{2/3}^{x_i} (V - p_i^T - p_i^S - t(1 - x))dx \\
W = TS + \sum_i (\pi_i^T + \pi_i^S)
\]

A.5 Vertical integration: profits, trader surplus and welfare in the second stage equilibrium

We calculate profit, trader surplus as well as welfare by plugging the equilibrium prices into the respective functions.

A.5.1 Non-integration

\[
\pi_i^T = \frac{4(t + 3v)^2}{675t} \\
\pi_i^S = \frac{75k^2 + 96v^2 + t(50k + 64v + 19t)}{900t} \\
\pi_i^T + \pi_i^S = \frac{225k^2 + 432v^2 + t(150k + 288v + 73t)}{2700t} \\
TS = \frac{225k^2 + 288v^2 + t(150k + 192v - 343t)}{1800t} \\
W = \frac{1152v^2 + 675k^2 + t(450k + 768v - 197t)}{1800t}
\]

A.5.2 Integration of A only

\[
\pi_i^{T,A} = \frac{28(78v + 26l - 21y)}{38025t}y \\
\pi_i^{S,A} = \frac{22100k - 15392l + 22362t + 29889y}{67600t} \\
\pi_i^T + \pi_i^S = \frac{91(155v + 52l - 57y)}{38025t}y \\
\pi_i^T + \pi_i^S = \frac{105300k - 121056l - 5252t + 137577y}{1216800t}
\]

\[
TS^A = TS + \frac{152100k - 129792l + 7436t + 203289y}{608400t} \\
W^A = W + \frac{456300k - 519168l - 20956t + 653931y}{608400t}
\]
From the table we can define $\Delta \pi(0)$:

$$(\pi_A^T + \pi_A^S) - (\pi_A^T + \pi_A^S) = \frac{198900k - 173472v + 8474t + 278499y}{608400t} \equiv y \Delta \pi(0)$$

### A.5.3 Integration of A and B

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<td>$\frac{\pi_i^T}{12675t}$</td>
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$$T S_{AB}^T = TS + \frac{253500k - 194688v + 19604t + 320769y}{608400t} \quad W S_{AB}^T = W + \frac{84500k - 767t + 86528v + 118539y}{67600t}$$

From the table we can define $\Delta \pi(1)$:

$$(\pi_B^T + \pi_B^S) - (\pi_B^T + \pi_B^S) = \frac{36075 k - 17784v + 6097t + 47160y}{152100t} \equiv y \Delta \pi(1)$$
A.5.4 Integration of all CSDs

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<td>$\pi_i^T + \pi_i^{S,AB}$</td>
</tr>
</tbody>
</table>

\[ TS^{ABC} = TS + \frac{25k - 16v + 3t + 33y}{50t}y = TS^{AB} + \frac{2028k + 676t + 3231y}{24336t}y \]

\[ W^{ABC} = W + \frac{225k - 192v + 11t + 321y}{150t}y = W^{AB} + \frac{2028k + 676t + 3135y}{8112t}y \]

From the table we can define $\Delta \pi(2)$, $\Gamma$ and $\Delta W$:

\[
(\pi_C^{T,ABC} + \pi_C^{S,ABC}) - (\pi_C^{T} + \pi_C^{S,AB}) = \frac{3588k + 1248v + 1612t + 4143y}{24336t}y \equiv y\Delta \pi(2)
\]

\[
(\pi_i^{T,ABC} + \pi_i^{S,ABC}) - (\pi_i^{T} + \pi_i^{S}) = \frac{75k - 72v + t + 111y}{225t}y \equiv y\Delta \Gamma
\]

\[
W^{ABC} - W = \frac{225k - 192v + 11t + 321y}{150t}y \equiv y\Delta W
\]

A.6 Proof of Lemma 3

In order to show this result, we need to calculate the difference between $\Delta \pi(1)$ and $\Delta \pi(0)$ and between $\Delta \pi(2)$ and $\Delta \pi(1)$.

\[
\Delta \pi(2) - \Delta \pi(1) = \frac{34112v + 5304t - 18200k - 28355y}{202800t} \quad (A.10)
\]

Note that the difference increases in $v$ while it decreases in $k$. The difference is positive for the highest possible $v = \frac{11}{12}t$ and the lowest possible $k = \frac{1}{2}t$ evaluated at $y = 0$. As the same is true for the highest possible $k = t$ and the lowest possible $v = \frac{1}{2}t$ the difference is always positive.

\[
\Delta \pi(1) - \Delta \pi(0) = \frac{34112v + 5304t - 18200k - 29923y}{202800t} \quad (A.11)
\]

As the terms do not differ evaluated at $y = 0$, this difference is also positive.
A.7 Comparison of \( \Delta \pi(0) \) and \( \Gamma \)

At \( y = 0 \) \( \Delta \pi(0) \) is negative for

\[
198900k + 8476t - 173472v < 0
\]

or if

\[
k < \frac{1112}{1275}v - \frac{163}{3825}t \tag{A.12}
\]

In contrast \( \Gamma \) is negative for

\[
75k + t - 72v < 0
\]

or if

\[
k < \frac{24}{75}v - \frac{1}{75}t \tag{A.13}
\]

The (positive) influence of \( v \) on the critical \( k \) is larger for Ineq. (A.12) than Ineq. (A.13). Similarly, the (negative) effect of \( t \) is smaller for Ineq. (A.13). Hence, the critical \( k \) is higher for \( \Gamma \) than for \( \Delta \pi(0) \) and \( \Gamma \) negative for a larger set of parameters.

A.8 Comparison of \( \Delta \pi(0) \) and \( \Delta W \)

At \( y = 0 \) \( \Delta W(0) \) is negative for

\[
225k + 11t - 192v < 0
\]

or if

\[
k < \frac{64}{75}v - \frac{11}{225}t \tag{A.14}
\]

The (positive) influence of \( v \) on the critical \( k \) is larger for Ineq. (A.12) than Ineq. (A.14) and the (negative) effect of \( t \) is smaller for Ineq. (A.12). Therefore, the critical \( k \) is higher for \( \Delta \pi(0) \) than for \( \Delta W \) and \( \Delta \pi(0) \) negative for a larger set of parameters.
A.9 Horizontal integration: prices, profits, trader surplus and welfare in the second stage equilibrium

With horizontal integration we derive from Eqs. (A.1)-(A.3) the following prices and demands in equilibrium:

\[ p_{i,H}^{T} = p_{i}^{T} + \frac{1}{5} by \]
\[ p_{ii,H}^{S} = p_{ii}^{S} - \frac{3}{5} by \]
\[ p_{ij,H}^{S} = p_{ij}^{S} - \frac{3}{5} by \]
\[ d_{i,H}^{i} = d_{i}^{i} \]
\[ d_{i,H}^{j} = d_{i}^{j} + \frac{2}{5} by \]
\[ \sum_{n} d_{n,H}^{j} = \sum_{n} d_{n}^{j} + \frac{4}{5} by \]

Finally, we find

\[ \pi_{i,H}^{T} = \pi_{i}^{T} + \frac{4(6v + 2t + 3by)}{225t} by \]
\[ \sum_{m} \pi_{m,H}^{S} = \sum_{m} \pi_{m}^{S} + \frac{8(6v + 2t + 3by)}{75t} by \]
\[ TS^{H} = TS + \frac{4(6v + 2t + 3by)}{75t} by \]
\[ WH = W + \frac{16(6v + 2t + 3by)}{75t} by \]