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Competition between clearing houses on the European market

Marie-Noëlle Calès*, Laurent Granier†, Nadège Marchand‡

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Abstract

For several years, European financial markets have been the place of important mutations. These mutations have hit both stock markets themselves as well as the infrastructures including all necessary services for the transactions on financial securities. Among the market services to which the investors appeal, is the clearing of the orders, the service which allows reducing exchanged flows while guaranteeing their safety. The market of clearing became strongly competitive with the arrival of new Pan European clearing houses. Confronted with aggressive pricing policies, "incumbent" clearing houses have to adopt new strategies: merger, simple or mutual links of interoperability. We develop a model of industrial organization to appreciate the consequences of these various strategies in terms of price and social welfare. The strategic incentives of clearing houses and their effects on their customers, *i.e.* investors, are observed by means of a sequential game. We show that the interoperability agreements are never reached at the equilibrium in spite of the fact that the "European code of good practice" of post-markets incites them to accept this type of agreements. On the other hand, a merger between incumbent clearing houses can occur under some conditions. The merger is beneficial to these last ones as well as to the investors, but it is unfavourable to the Pan European clearing houses.

JEL classification: L10 ; G15 ; G20 ; G34.

Key words: bundling, clearing house, interoperability, merger, post-market organization.

Mots clefs : ventes liées, chambre de compensation, fusion, organisation des post-marchés.

1 Introduction

For several years, European financial markets have been the place of important mutations. These mutations have hit both stock markets themselves as well as the infrastructures including all

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necessary services for the transactions on financial securities (Milne, 2007). These transformations were impulsed notably by the European authorities which aim at setting up a wide European financial market. They took the shape of mergers between stock exchanges as for instance the attempt of connection between Deutsche Börse and NYSE Euronext.[1] Another example is the implementation of a system of secured exchange of securities common to the whole Eurozone under the leadership of the European Central Bank (Target 2 Securities which will be effective in 2014).

The clearing appears among the services to which appeal investors on markets. Once the negotiation led on a market, the securities are the object of an exchange (service of delivery *vs* payment), then of a procedure of recording of the new owner (depositary service); in many cases, after the negotiation but before the delivery, the securities can pass in transit by clearing houses. The service sold by these clearing houses consists of a clearing of flows, which reduces the exchanges and the liquidity needs of the investors. Besides, the clearing allows to decrease the default risk of the counterparties. Indeed, clearing houses ask their customers to make deposits, so assuring the default risk (Mendelson, 1982, Wendt, 2006, Bernanke, 2008).

Since a few months, the clearing market has evolved with the emergence of new actors in Europe, such as Pan European clearing houses. On one hand, on the European market, appeared the branches of houses pre-existent abroad as, for instance, Euro CCP. This clearing house is a subsidiary of the American house DTCC. On the other hand, Pan European houses were created *ex nihilo* like EMCF. These new clearing houses have in common that they weaken their fixed costs on several countries, by specializing themselves on some types of securities. The incumbent houses, from their part, generally handle a wide range of products but are settled in a single country. The new clearing houses can amortize their fixed costs on several countries, so that they develop aggressive pricing policies. We can so observe that in a few months, the incumbent French house LCH Clearnet, leader of the equities market, has just lost its first place for the benefit of EMCF.

The European Commission has adopted a new directive in 2004, the MiFID[2] which made the competition stronger on the clearing market.[3] On one hand, the MiFID induced the adoption of a new code called "European code of conduct for clearing and settlement" set up in 2006. This one requests the houses to open their networks to foreign clearing houses and to charge them this service at cost price in order to develop the interoperability in Europe (Schaper, 2008). On the other hand, the MiFID encouraged new modes of negotiation of securities, appeared such as multilateral trading platforms which give access to several European markets. The new clearing houses were born to offer exactly these trans national services of clearing, what did not offer traditional houses.[4]

[1] This merger has just been rejected by the European Commission. Other important mergers occurred in 2011 (LSE / Turquoise & BATS / CHI-X).

[2] The MiFID (Markets in Financial Instruments Directive), was voted to promote the harmonization and the opening of the European markets, in particular by means of a greater integration of their infrastructures.

[3] From 2004, a European directive, the MiFID (Markets in Financial Instruments Directive), was voted to promote the harmonization and the opening of the European markets, in particular by means of a greater integration of their infrastructures.

[4] Leaning on these new clearing houses in full development, some stock exchanges are questioning their privileged link with their incumbent clearing houses (for example the recent announcement of NYSE Euronext which

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In that context, how can the incumbent clearing houses resist in front of the arrival of these new Pan European houses? Could we attend phenomena of mergers between incumbent clearing houses allowing synergies on several markets? Could a simple connection of their networks be a solution such as considered by the European Commission? Finally what will be the anticipated consequences for investors?

The imperfect competition between clearing houses justifies the use of a model coming from industrial economics. Each incumbent clearing house has a privileged link with a domestic stock exchange, so that the European market is segmented. In some cases, clearing houses can disregard this segmentation by supplying bundles connected to several markets. To take into account these two characteristics, we adapt a model analyzing bundling strategies (Thanassoulis, 2011). We take into consideration several market structures for which we determine the prices, the market shares and the clearing houses' profits as well as the consequences for investors. We develop a non cooperative game in two stages in order to determine the market structures which appear.

Our model allows us to show that, first, the competitive reference situation is favourable to the Pan European clearing house. Secondly, any strategy modifying this situation has a widely negative effect on the profit of this Pan European house. We show that the effect on the profit of the incumbent houses depends widely on the fixed costs structure. Thirdly, the investors surplus increases in an identical way with the strategies of mergers or interoperability.[5] Finally, we show that the strategies of the clearing houses never lead to interoperability agreements. Under some conditions, the merger is the only sustainable outcome.

In section 2, we explain the choice of the model. Then we apply this one to a competitive framework in which a Pan European clearing house compete with two incumbent houses. It is the benchmark of our study. We consider then in section 3 the other competitive frameworks. On one hand, the incumbent houses set up several interoperability agreements. On the other hand, we consider the case of a merger between these same houses. In section 4, we analyze the incentives of clearing houses to adopt strategies leading to these various competitive frames. Finally, the section 5 concludes.

2 Literature and basic model

2.1 Related literature

Some clearing houses propose a bundle of their services on several markets. There is an important literature on this type of sales[6] which can break it down into two main categories.[7] In any case, this literature focuses on the incentives to practise bundles and on the effects of such a strategy in

announced, for 2012, the end of its trade agreement with LCH Clearnet).

[5]The agreements of interoperability allow a clearing house to clear orders exchanged on a foreign market.

[6]When a firm sells its products only in the form of bundles, we speak about pure strategy of bundling. When a company sells also its products separately, we speak about mixed strategy of bundling.

[7]Note that several papers from these two categories focuse on non linear tariffs. Refer to Armstrong (1996), Armstrong and Vickers (2001 and 2010).

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terms of profit and consumer surplus. A first category concerns the incentives to practise bundles in a monopolistic situation.[8] Analyzing competitive markets, this side of the literature does not concern this paper. The second category analyzes bundles in a competition context. The literature can then be subdivided according to the number of firms which are capable of bundling their goods, i.e. the firms which are active on several markets at the same time. This makes reference to the degree of convergence of the industry. This one can be modified, in particular, by the merger of two companies supplying each only one product.

We now give more details about the second category of the bundling literature. A first series of papers studies the total convergence, often represented by two companies competing on two markets at the same time. A first difference between the models concerns the type of differentiation in terms of products or firms. Another difference is about the setting up of groups of buyers, some buying all the distributed goods and the others not.[9] The second serie of papers analyzes a partial convergence of the industry. We can quote Nalebuff (2000) who models a competition between a firm acting on several markets and independent firms on each of these markets.[10] Then, some other papers study the process of convergence, as Granier and Podesta (2010). They consider two markets with two firms on each of them. They study the incentives to achieve partial or total convergence via mergers on these two markets. The differentiation is then between products and consumers purchase systematically on both markets. Thanassoulis (2011) adopts the same model type than Granier & Podesta but in setting up groups of buyers and assuming that the differentiation is between firms.

We get closer to this last model of two manners. In the first place, we consider a horizontal differentiation because we suppose that products do not offer qualitative differences.[11] The clearing services are similar from a clearing house to the other one, what explains that these houses compete more on the associated services or simply on the services accessibility.[12] The incumbent houses benefit from habits of consumption of investors, which justifies well a differentiation between firms and not between products. Secondly, we take into account the existence of several groups of buyers. Some investors make clear their orders only on one market while the others make it on several markets.

On the contrary, we distance ourselves from this model on four main points. The first one is linked with the analyzed scenarios and with the occurrence of bundling strategies. Thanassoulis begins by studying a market structure in which four firms compete two by two, on two different markets. Bundling strategies are then possible as soon as two firms at least merge. The starting point of our study is focused on an industry where two clearing houses are competitors, each on a different

[8] Adams and Yelen (1976), McAfee and al. (1989), Whinston (1990), Nalebuff (2004) and Peitz (2008).

[9] In notorious articles of Matutes and Regibeau (1992), Anderson and Leruth (1993) and Reisinger (2006), the differentiation is between products and all the consumers buy both goods while Thanassoulis (2007) assumes a differentiation between firms as well as setting up groups of consumers. Armstrong and Vickers (2010) extend this analysis to a more general demand.

[10] Nalebuff (2000) considers that all the consumers buy systematically on all the markets and that the differentiation is between products.

[11] Knowing that we suppose that the cleared securities are of the same nature, it is reasonable to assume that the risks are identical between clearing houses.

[12] For example, clearing houses can favour the compatibility of their information systems with those of their customers.

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market, a third one acting on both markets.[13] In our reference situation, we so make the hypothesis of a partial convergence, as far as this last clearing house is bundling its products. Secondly, the strategies of convergence are not only the fruit of a merger between houses, but can result also from interoperability agreements. Thanks to these agreements, the houses "mono-market" can disregard the segmentation of their market by supplying bundles. These interoperability agreements can be mutual or not, between the concerned houses and are characteristic of this type of activity.[14] The third difference concerns the determination of the market structures which becomes endogenous in our model. Finally, we introduce fixed costs which can differ according to the market structures. In fact, the clearing market is characterized by high fixed costs.

2.2 Model and benchmark

We build a non cooperative game in two stages. In the first stage, the incumbent clearing houses choose between several strategies leading to diverse competitive situations; then, in the second stage, the houses enter competition. We suppose that three houses give access to the clearing onto two markets physically separated, named X and Y. The securities cleared on each of these markets are of the same nature,[15] this allowing us to make the hypothesis that the incurred risks are similar. A Pan European clearing house can clear the orders on both markets while the two other incumbent houses confine themselves to their respective markets. Banks are the customers of the clearing houses[16] and they divide up into three groups. Banks clearing only on the market X (respectively on the market Y) are quoted by the proportion X (respectively Y). We quote B the proportion of banks dealing on both markets.[17] We suppose that the proportions X, Y and B are positive. Each market is horizontally differentiated and represented by a segment of a unit length like in the Hotelling model.[18] Banks are uniformly distributed between clearing houses and each of them has a location θ, with $\theta \epsilon [0, 1]$. The incumbent houses (named X_1 et Y_1) are located at the point 0 of each segment, the Pan European house (XY_2) being located at point 1 *i.e.* at the opposite. The Pan European house offers access to some banks. It so differs from incumbents by using information systems more easily compatible with those of these banks. Figure 1 allows visualizing these locations:

[13]This house is characteristic of the current clearing market in Europe. It is a new type of clearing houses which allows to clear stock exchange orders from several markets. To quote an example, the EMCF clearing house allows to clear securities exchanged on a multilateral trading platform giving access to fourteen different markets.

[14]These interoperability links are moreover encouraged by the "European code of conduct for clearing and settlement".

[15]For instance, we can suppose that it is about stock markets.

[16]The investors customers of clearing houses are generally bound with houses through banks. Afterward, we so choose to simplify to use the term of bank to refer to the customers of clearing houses.

[17]In Europe, customers' proportion needing to compensate orders on several markets is of the order of 2/3

[18]Let us remind that on one hand the differentiation is horizontal because there is no qualitative difference between the several clearing services. On the other hand, the differentiation is made at the level of firms like as it is explained in the section 2.1.

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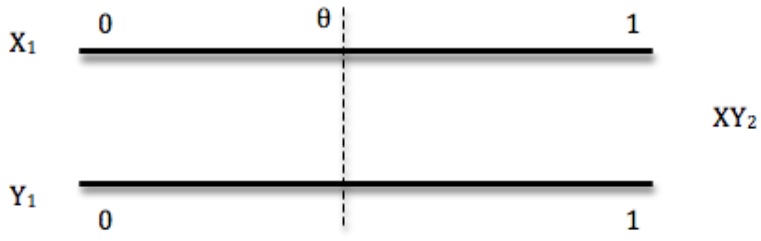

Figure 1: localization of the clearing houses.

As in the Hotelling model, banks endure transportation costs respectively quoted t_X et t_Y for markets X and Y. Those which want to clear orders coming from two markets can so realize economies of scope by addressing the same clearing house. So, the transportation cost is paid only once for the clearing of both orders. It is the "one stop shopping" principle. It allows in particular to save costs of information systems adaptation imposed by the access on two different clearing houses. This transportation cost is named t_B with $t_B < t_X + t_Y$. As the degrees of competition (*i.e.* of differentiation) are similar on both markets, we standardize these three transportation costs at 1. Finally, each clearing house endures fixed costs to practice its activity,[19] quoted F_1 for the incumbent clearing houses and F_2 for the Pan European house.

In the benchmark, the Pan European house follows a mixed bundling strategy as far as it proposes the clearing on both markets as a package, but also the clearing on both markets separately. It is the only strategy allowing it to capture the three types of banks X, Y et B.[20] The quotations for the tariffs of the clearing houses are as follows : p_{x_1} for the incumbent house on the market X, p_{y_1} for the incumbent house on the market Y, p_{x_2} for the Pan European house on market X, p_{y_2} for the Pan European house on market Y and finally p_b for the Pan European package supply.

For each market, we determine the localization of the bank which is indifferent to purchase at point 0 (*i.e.* an incumbent) and to purchase at point 1 (*i.e.* the Pan European). This bank is called the marginal bank afterward. We quote them $\tilde{\theta}$ indexed by X, Y or B according to the type of concerned banks.[21]

$$\tilde{\theta}_X = \frac{1 + p_{x_2} - p_{x_1}}{2}, \tag{1}$$

$$\tilde{\theta}_Y = \frac{1 + p_{y_2} - p_{y_1}}{2}, \tag{2}$$

[19] For such institutions, the fixed costs are high and the variable costs can be considered null

[20] In fact, at equal margin on package and separate sales, this mixed strategy allows the Pan European clearing house to make benefit to the banks of type B from consumption savings and to compete directly with the houses X_1 and Y_1 concerning banks of type X et Y.

[21] We find here a particular case of the equilibrium of partial convergence of Thanassoulis (2011). He shows that at the equilibrium, it is not possible that the consumers of type B made hybrid purchases, *i.e.* at the same time in 0 for a market segment and in 1 for the other segment. Furthermore, the equilibrium exists if $t_X = t_Y$, which is in accordance with our hypotheses. For more details, refer to the lemmas 1 and 2 of Thanssoulis (2011).

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$$\tilde{\theta}_B = \frac{1 + p_b - p_{x_1} - p_{y_1}}{3}. \tag{3}$$

Profits respectively indexed Π_{X_1}, Π_{Y_1} et Π_{XY_2} for the houses X_1, Y_1 and XY_2 have the following shape :

$$\Pi_{X_1} = p_{x_1}(X\tilde{\theta}_X + B\tilde{\theta}_B) - F_1, \tag{4}$$

$$\Pi_{Y_1} = p_{y_1}(Y\tilde{\theta}_Y + B\tilde{\theta}_B) - F_1, \tag{5}$$

$$\Pi_{XY_2} = p_{x_2}X(1 - \tilde{\theta}_X) + p_{y_2}Y(1 - \tilde{\theta}_Y) + p_b B(1 - \tilde{\theta}_B) - F_2. \tag{6}$$

From the first order conditions on profits,[22] we compute the equilibrium prices and we deduct the conditions of market sharing defined by the marginal banks[23] :

Lemma 1 *At the equilibrium of the competitive game, prices are given by* $p^*_{x_1} = p^*_{x_2} = p^*_{y_1} = p^*_{y_2} = 1$, $p^*_b = 2$ *and marginal banks by* $\tilde{\theta}^*_X = \tilde{\theta}^*_Y = \frac{1}{2}$ *et* $\tilde{\theta}^*_B = \frac{1}{3}$.

We deduct from Lemma 1 the market shares of each clearing house :

Market shares	House X1	House Y1	House XY2
Market X	1/2		1/2
Market Y		1/2	1/2
Market B	1/3		2/3

Table 1 : Market shares of clearing houses in the benchmark

Proposition 1 *The Pan European clearing house does not offer discounts on its bundles. Nevertheless, it gets two thirds of banks appealing to the clearing on two markets.*

Because of savings in transportation costs realized by the banks B which address the Pan European house, this one monopolizes 2/3 of them. So profits are as follows at the equilibrium[24] :

$$\Pi^*_{X_1} = \frac{1}{2}X + \frac{1}{3}B - F_1, \tag{7}$$

$$\Pi^*_{Y_1} = \frac{1}{2}Y + \frac{1}{3}B - F_1, \tag{8}$$

$$\Pi^*_{XY_2} = \frac{1}{2}X + \frac{1}{2}Y + \frac{4}{3}B - F_2. \tag{9}$$

[22] For more details, please refer to Appendix A.
[23] All equilibrium values are spotted by a star.
[24] The profit and the banks surplus at the equilibrium are discussed and compared in section 4.

We quote ϕ_X and ϕ_Y, the gross utilities from the clearing of orders X and Y respectively. The total surplus for the banks at the equilibrium is given by[25] :

$$S^* = X\phi_X + Y\phi_Y + B(\phi_X + \phi_Y) - \frac{9}{8}(X+Y) - \frac{59}{27}B. \tag{10}$$

3 Interoperability and Merger

In order to resist to the competitive pressure of the Pan European house, the incumbent clearing houses can adopt three strategic options. According to the recommendations made by the European Union to open up the national markets, the incumbent houses can develop agreements of interoperability between them.[26] The signature of these agreements can be of two types. A clearing house can open its market to the other one and it is then a link of simple interoperability, without reciprocity. Both houses can also offer themselves mutually the access to their respective markets and, in that case, the interoperability is said bilateral or mutual. The cost led by this type of arrangement cannot be neglected for the house.[27] On one hand, it must be acting on a new market and, on the other hand, it has to pay the clearing house supplying it the access. As defined by the code of conduct, a clearing house should not refuse a request of interoperability. Furthermore, the code recommends aligning tariffs of access on its costs. In the model, an incumbent clearing house cannot refuse the access to its market, even if this opening does not get it an additional profit. Another solution to resist the competition is the merger strategy. Both incumbent houses can then decide to merge their activities in order to reduce their costs thanks to the synergy effects.

These three options allow the incumbent houses to offer an acces to banks on both markets and so to compete directly with the Pan European clearing house. These strategies are all the more relevant as the great majority of banks ask for multiple accesses (banks of type B in our model). In that context, banks B benefit from ***savings of consumption cost***. From the incumbent clearing houses point of view, the level of fixed costs is of a major importance as it conditions their presence on the market. Which structure will allow the incumbent clearing houses to realize most profits? This question remains opened because it is deeply linked to the success of the merger and to the difficulties of setting-up on another market. More simply, we suppose that these rival alternatives allow the incumbent houses to widen their market. So they benefit from economies of scale by possibly reducing their fixed costs.

3.1 Agreement of simple interoperability

For a given incumbent house, the first fighting strategy against the competition of the Pan European house consists in negotiating an agreement of interoperability with the other incumbent house. We suppose that it is the house X_1 which asks for a link of interoperability to Y_1.[28] X_1 is then going

[25] Fore more details, please refer to Appendix B .

[26] Refer to the Code of conduct of the European Commission.

[27] In fact, the clearing house has to create an infrastructure located on the same geographical place as the incumbent house giving the access. This involves additional fixed costs.

[28] We do not deal with the symmetric case. Results are obviously the same.

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to endure a fixed cost of interoperability quoted f, with $f < F_1$. In fact, the house X_1 does not need to build complex links with a new market, but simply some links with the house Y_1 which gives it access to its market. We add two hypotheses which are necessary for the existence of an interoperability agreement. On one hand, the banks B do not buy separated accesses to both markets.[29] The bundle is henceforth proposed to them by the incumbent house X_1 besides the Pan European one. On the other hand, the banks Y never address the house X_1 in spite of the existence of a new link of interoperability.[30]

The price p_{b_1} indicates now the price of the bundle sold by X_1 and p_{b_2} indicates now the price of the bundle sold by XY_2. The quotations are indexed by I to refer to the interoperability. The distribution of banks between clearing houses is made in the following way[31] :

$$\tilde{\theta}_{XI} = \frac{1 + p_{x_2} - p_{x_1}}{2}, \tag{11}$$

$$\tilde{\theta}_{YI} = \frac{1 + p_{y_2} - p_{y_1}}{2}, \tag{12}$$

$$\tilde{\theta}_{BI} = \frac{1 + p_{b_2} - p_{b_1}}{2}. \tag{13}$$

Profits have the following shape:

$$\Pi_{X_1 I} = p_{x_1} X \tilde{\theta}_{XI} + p_{b_1} B \tilde{\theta}_{BI} - F_1 - f, \tag{14}$$

$$\Pi_{Y_1 I} = p_{y_1} Y \tilde{\theta}_{YI} - F_1, \tag{15}$$

$$\Pi_{XY_2 I} = p_{x_2} X (1 - \tilde{\theta}_{XI}) + p_{y_2} Y (1 - \tilde{\theta}_{YI}) + p_{b_2} B (1 - \tilde{\theta}_{BI}) - F_2. \tag{16}$$

Appendix C allows settling the following lemma :

Lemma 2 *Equilibrium prices are identical and equal to* 1*, let* $p^*_{x_1} = p^*_{x_2} = p^*_{y_1} = p^*_{y_2} = p^*_{b_1} = p^*_{b_2} = 1$ *and the marginal banks are defined by* $\tilde{\theta}^*_{XI} = \tilde{\theta}^*_{YI} = \frac{1}{2}$ *et* $\tilde{\theta}^*_{BI} = \frac{1}{2}$.

We deduct from lemma 2 the respective market shares of clearing houses :

[29] Whatever is the reduction in the price granted by the clearing house Y_1, this one cannot keep banks on market B. These type of banks prefer to buy the bundle because, even if Y_1 sets a zero price, the bundle price cannot be lower than the price of X.

[30] The clearing house X_1 cannot lead an aggressive pricing policy on this market segment Y because this strategy would bring the house Y_1 out of the market. In this case, it could not any more access the market Y to satisfy the package demand. Furthermore, these banks are inevitably already customers of the house Y_1 and have no interest to change their supplying house.

[31] In the benchmark, hybrid purchases have been drawn aside. Given that bundles are now available on the location 0, hybrid purchases are even less likely to occur in this configuration. It's the same in sections 3.2 and 3.3. In fact, the price of the bundles cannot be upper to the price of both separate sales.

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Market shares	House X1	House Y1	House XY2
Market X	*1/2*		*1/2*
Market Y		*1/2*	*1/2*
Market B	*1/2*		*1/2*

Table 2: Market shares of clearing houses in the situation of simple interoperability.

Proposition 2 *The agreement of simple interoperability creates a discount on the bundles so that all the services are supplied at the same price. The Pan European clearing house and the incumbent house benefiting from the interoperability agreement are sharing this market into two equal shares. Markets of separate services are not impacted by the agreement.*

The competition between the bundles on the market B lowers the price of packages. Clearing houses X_1 and XY_2 continue to supply separated accesses to both markets although the separate and grouped accesses are proposed at the same price. If one of them decided not to supply any more separate accesses, the other one could lower its separate sales prices and gets all the banks needing only one service of clearing. The anticipations being symmetric, there is so no unilateral deviation. Both houses carry on to propose both types of sales, *i.e.* grouped or separate (type X and B by X_1 and type X,Y and B by XY_2).

At the equilibrium, profits are so as follows :

$$\Pi^*_{X_1 I} = \frac{1}{2}X + \frac{1}{2}B - F_1 - f, \tag{17}$$

$$\Pi^*_{Y_1 I} = \frac{1}{2}Y - F_1, \tag{18}$$

$$\Pi^*_{XY_2 I} = \frac{1}{2}X + \frac{1}{2}Y + \frac{1}{2}B - F_2. \tag{19}$$

Let us note that if $F_1 > \frac{1}{2}Y$, the clearing house Y_1 gets out of the market and two cases are then possible. Because of the disappearance of this house, the house X_1 cannot then offer any more service of clearing on Y despite the interoperability agreement . If $F_1 > \frac{1}{2}X$, the Pan European house monopolizes all markets and the house X_1 also disappears. If, on the contrary, $F_1 < \frac{1}{2}X$, the house X_1 remains active on the market X that it shares into two with the Pan European, this last one monopolizing the Y market.

Finally, the total surplus for the banks at the equilibrium of simple interoperability is[32] :

$$S^*_I = X\phi_X + Y\phi_Y + B(\phi_X + \phi_Y) - \frac{9}{8}(X + Y + B). \tag{20}$$

[32]Please refer to Appendix D for more details.

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3.2 Agreement of bilateral interoperability

In this alternative scenario, both incumbent clearing houses choose to ask for an agreement of mutual interoperability to their counterpart. To assure the reality of the interoperability agreements, we keep both hypotheses made previously. Both incumbent houses endure an additional fixed cost f and are in competition on market B. As they have the same location, they cannot differ any more from one of the other one, on market B. We observe a paradox of Bertrand which would end in null incomes for these two houses on market B. So these ones should rather agree on an identical price[33] and share the part of the market B left vacant by the Pan European house in this competitive game. This price is quoted p_{b1} as in the previous case. All the following quotations are indexed DI for double interoperability.

The two houses X_1 and Y_1 sharing their sales on market B, profits are so as follow :

$$\Pi_{X_1 DI} = p_{x_1} X \tilde{\theta}_{XDI} + \frac{1}{2} p_{b_1} B \tilde{\theta}_{BDI} - F_1 - f, \tag{21}$$

$$\Pi_{Y_1 DI} = p_{y_1} Y \tilde{\theta}_{YDI} + \frac{1}{2} p_{b_1} B \tilde{\theta}_{BDI} - F_1 - f, \tag{22}$$

$$\Pi_{XY_2 DI} = p_{x_2} X (1 - \tilde{\theta}_{XDI}) + p_{y_2} Y (1 - \tilde{\theta}_{YDI}) + p_{b_2} B (1 - \tilde{\theta}_{BDI}) - F_2. \tag{23}$$

At the equilibrium, we find the same prices as in the previous case.[34] The distribution of banks is synthesized in the following table 3 :

Market shares	House X1	House Y1	House XY2
Market X	1/2		1/2
Market Y		1/2	1/2
Market B	1/4	1/4	1/2

Table 3: Market shares of clearing houses in the situation of bilateral interoperability

Proposition 3 *Clearing houses adopt the same pricing strategies in the simple and double interoperability agreements. The earnings associated to the interoperability are now shared between the incumbent houses.*

Nevertheless, profits differ from simple interoperability because, in this market configuration, both incumbent houses are acting on the market of bundles. At the equilibrium, we obtain the following profits:

$$\Pi^*_{X_1 DI} = \frac{1}{2} X + \frac{1}{4} B - F_1 - f, \tag{24}$$

[33] Furthermore, a unilateral detour of one of both houses on this price would engender an exclusion of the rival incumbent clearing house from this market. It could drive to a total eviction of this one because of the fixed costs linked to the interoperability, rendering then the interoperability agreement null and void.

[34] For further details, please refer to Appendix E.

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$$\Pi^*_{Y_1DI} = \frac{1}{2}Y + \frac{1}{4}B - F_1 - f, \tag{25}$$

$$\Pi^*_{XY_2DI} = \frac{1}{2}X + \frac{1}{2}Y + \frac{1}{2}B - F_2. \tag{26}$$

Prices, as well as the distances crossed by banks are identical to the previous case and their total surplus is so the same.[35]

$$S^*_{DI} = S^*_I \tag{27}$$

3.3 Mergers

A merger between both incumbent clearing houses also presents advantages in terms of fixed cost and ***economy of consumption***. We shall quote F_M the fixed cost endured by the unique entity stemming from the merger. We suppose that $F_M < 2F_1$ because economies of scale can be realized thanks to the merger. The index F makes reference to the merger. The packages prices are now p_{b_2} for the Pan European firm and p_{b_1} for the merged firm which is called X_1Y_1. The distribution of banks between the merged entity and the Pan European clearing house is made in the same way as for the previous agreements of interoperability :

$$\tilde{\theta}_{XM} = \frac{1 + p_{x_2} - p_{x_1}}{2}, \tilde{\theta}_{YM} = \frac{1 + p_{y_2} - p_{y_1}}{2}, \tilde{\theta}_{BM} = \frac{1 + p_{b_2} - p_{b_1}}{2}. \tag{28}$$

Profits have so the following shape:

$$\Pi_{X_1Y_1M} = p_{x_1}X\tilde{\theta}_{XM} + p_{y_1}Y\tilde{\theta}_{YM} + p_{b_1}B\tilde{\theta}_{BM} - F_M \tag{29}$$

$$\Pi_{XY_2M} = p_{x_2}X(1 - \tilde{\theta}_{XM}) + p_{y_2}Y(1 - \tilde{\theta}_{YM}) + p_{b_2}B(1 - \tilde{\theta}_{BM}) - F_2 \tag{30}$$

From the first order conditions on profits, we obtain the same prices at the equilibrium as in both previous cases. Clearing houses are sharing each market (X, Y et B) in two[36], as it is indicated in Table 4 :

Market shares	Merger between X1 and Y1	House XY2
Market X	1/2	1/2
Market Y	1/2	1/2
Market B	1/2	1/2

Table 4: Market shares of clearing houses after merging.

[35]For further details, please refer to Appendix F.
[36]For further details, please refer to Appendix G.

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The profits at the equilibrium are then as follows:

$$\Pi^*_{X_1Y_1M} = \frac{1}{2}X + \frac{1}{2}Y + \frac{1}{2}B - F_M \tag{31}$$

$$\Pi^*_{XY_2M} = \frac{1}{2}X + \frac{1}{2}Y + \frac{1}{2}B - F_2 \tag{32}$$

The total surplus for the banks at the equilibrium is identical to the cases of interoperability, as[37] :

$$S^*_F = S^*_I = S^*_{DI} \tag{33}$$

Proposition 4 *At the equilibrium, for all the alternative market configurations to the benchmark (agreements of simple or bilateral interoperability, merger), the prices of the offered services are identical and the three markets are shared in two equal shares : one half fot the Pan European house and the other one shared between the incumbent clearing houses.*

4 Strategic incentives

In this section, we resolve the first stage of the non-cooperative game. We so look for the Subgame Perfect Nash Equilibrium (SPNE) of the global game. It is important to underline that the Pan European clearing house does not take part in the first stage of this game. In fact, this house is only adapting itself to the choices of the incumbent clearing houses in maximizing its profit being given the competitive situation (see Table 5).

In this first step, the incumbent clearing houses X_1 and Y_1 can request a merger between themselves, ask for an agreement of interoperability, either opt for the status quo. This subgame is non cooperative and their decision-making are simultaneous. The merger occurs at the first stage only if both houses propose it. The profit of merger is then simply shared in two between both incumbent houses as these are initially in a symmetric situation. If a house asks for an agreement of interoperability, this one is necessarily accepted considering the code of conduct on clearing and settlement. Finally, if both houses ask for the interoperability, we reach a situation named bilateral interoperability. In all other cases, we observe the status quo, corresponding to the benchmark. This non cooperative game can be summarized as :

$< N = 2, \{status\, quo, interoperability, merger\}, \Pi = (\Pi_i)\, with\, i = X_1, Y_1 >.$

On the market of clearing,[38] we suppose that 72 % of the clientele wishes to make operations on the market B, the remaining 28 % being also equally distributed on markets X and Y so that the sizes of markets X and Y are identical and equal to 14 %. The results obtained for these values are summarized in Table 5 following :

[37] For the detail of the calculations, refer to the Appendix H

[38] These sizes of markets are recovering from the empirical reality and are integrated into an additional experimental study (voir Calès et al., 2012).

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	$\Pi^*_{X_1}$	$\Pi^*_{Y_1}$	$\Pi^*_{XY_2}$	S^*
Benchmark	$31 - F_1$	$31 - F_1$	$110 - F_2$	$86(\phi_X + \phi_Y) - 188,83$
Inter operability X	$43 - F_1 - f$	$7 - F_1$	$50 - F_2$	$86(\phi_X + \phi_Y) - 112,5$
Inter operability Y	$7 - F_1$	$43 - F_1 - f$		
Merger	$25 - \frac{F_M}{2}$	$25 - \frac{F_M}{2}$		
Bilatéral inter operability	$25 - F_1 - f$	$25 - F_1 - f$		

Table 5: Houses profits et banks surplus

Proposition 5 *The benchmark is favourable to the Pan European clearing house and unfavourable to banks :*

5.1 *Any strategy modifying this situation has a widely negative effect on the profits of the Pan European house and an ambiguous effect on those of the incumbent houses.*

5.2 *Banks, customers of clearing houses, see their surplus increasing in a identical way with the mergers and the agreements of interoperability.*

In this analysis, the level of fixed costs is crucial to define the equilibria of the game. On one hand, we suppose that the fixed costs F_1 endured by each incumbent clearing house are lower than those of the Pan European house quoted F_2. In fact, this last one operates on both markets while an incumbent house is initially settled only on one of them. On the other hand, the Pan European house benefits from economies of scale so that $2F_1 > F_2$. The merged incumbent houses also benefit from economies of scale $2F_1 > F_M$, but nothing allows to suppose a priori that they are identical. It is not so possible to define a link between the fixed costs of the merged houses and those of the Pan European house. Furthermore, it is reasonable to think that the fixed costs associated to the operations of simple interoperability generate fixed costs lower than those endured initially by the incumbent houses. So, the interoperability presents the advantage to allow the range of services of clearing on another market without having to endure all the costs of settlement i.e. is to double the amount of the fixed costs. The incumbent clearing house which grants the access to its market opens its system of clearing, but the new entering company has to make its system compatible. Although expensive, this operation does not lead fixed costs superior to the costs of a complete installation of a competitor on the market and so $f < F_1$. It is then possible to arrange in order

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the level of the fixed costs in the following way :

$$f < F_1 < F_M < 2F_1 \; and \; F_1 < F_2 < 2F_1. \tag{34}$$

To remain on their markets, clearing houses have to have a positive profit or null. Therefore, the condition of existence of the benchmark, $F_1 < 31$, is not a sufficient condition in the realization of all the scenarios. So that all the issues of the game are practicable, it is necessary that $F_1 < 7$. Under this hypothesis, the matrix of the earnings of the incumbent houses is represented in Table 6.

Y1 / X1	*Status quo*	Inter operability	Merger
Status quo	$31 - F_1$; $31 - F_1$	$7 - F_1$; $43 - F_1 - f$	$31 - F_1$; $31 - F_1$
Inter-operability	$43 - F_1 - f$; $7 - F_1$	$25 - F_1 - f$; $25 - F_1 - f$	$43 - F_1 - f$; $7 - F_1$
Merger	$31 - F_1$; $31 - F_1$	$7 - F_1$; $43 - F_1 - f$	$25 - \frac{F_M}{2}$; $25 - \frac{F_M}{2}$

Table 6: The matrix of the earnings

We establish now the Subgame Perfect Nash Equilibrium.

Lemma 3 *The SPNE depends on conditions on the fixed costs. The merger equilibrium appears if at the same time* $12 < F_1 < 31$ *and* $F_1 > 6 + \frac{F_M}{2}$. *In all other cases, the benchmark is the only equilibrium of the game.*[39]

Proposition 6 *The strategies of clearing houses never lead to the agreements of interoperability. On the other hand, the merger can come true if it generates enough fixed costs savings.*

Simple interoperability outcome is never an equilibrium of the game ; as such an agreement would be too harmful for the incumbent clearing house which grants it. On one hand, by accepting such an organizational arrangement, it would see its competitive environment strongly degrading because it would automatically be relegated to its "natural" market in the narrowest sense, without having been able to decrease the competitive pressure which exercises the Pan European house. On the other hand, the incumbent house which would benefit from the interoperability could offer bound accesses to the banks of the market B, while reducing its handicap on fixed costs. Nevertheless, the bilateral agreements of interoperability neither represent a credible alternative for the incumbent clearing houses as such strategies do not allow them any more to differ enough. Therefore, houses would meet in direct competition on prices which, from a strategic point of view,

[39] Proofs : refer to appendix I.

is the worst possible situations. This explains why the implementation of a link of interoperability is so difficult in spite of the opportunities offered by the regulator in terms of pricing and acceptance of such a request. The merger can be the equilibrium of the game if savings in generated fixed costs are rather big. When the merger occurs, it is moreover beneficial for incumbent clearing houses and banks. It is on the other hand unfavourable to the Pan European house. In all other cases, the market structure keeps its shape of origin, what represents the best of the situations for the Pan European house but the worst for banks.

5 Conclusion

In this article, we studied the impact of the arrival of new incoming clearing houses. To face this competitive pressure, incumbent houses can adopt different strategies: status quo, interoperability agreements or merger.

The agreements of interoperability are never reached at the equilibrium despite of the fact that the code of conduct of the post-markets incites to accept this type of agreements. The failure of the implementation of links of interoperability between the incumbent clearing houses is understandable by the structure of this market. As most of the banks ask for a multiple access to houses (market B), a bundle allows them to obtain significant economies of scope. This structure of the demand of clearing explains the recent success of the Pan European houses whose bundle corresponds to the demand of this clientele. To propose a similar offer by using a link of interoperability seems interesting first. On one hand, the mutualisation of the infrastructures of clearing limits the fixed costs and, on the other hand, the pricing settled by the code of conduct avoids locking them by a prohibitive unit cost. Nevertheless, this option is hardly possible for the incumbent clearing houses which cannot stay isolated on their markets. If they cannot refuse a link of interoperability, they have to ask for an agreement of reciprocity and end in a bilateral agreement. By adopting such a strategy, the incumbent houses have to face a harder competitive pressure. This type of agreement made the incumbent houses lose a big portion of their specificities. They are then confronted with a fierce competition between them besides the one exerted by the Pan European house. It is important to underline that, in this configuration, all clearing houses, incumbent and Pan European, see their profits decreasing to the advantage of banks. .

That is why the merger is the equilibrium of the game if generated savings in fixed costs are rather big. When the merger occurs, it is so beneficial in incumbent clearing houses and in banks but it is unfavourable to the Pan European house. In all other cases, the market structure keeps its initial shape, this representing the best of the situations for the Pan European house but the worst for banks.

Several extensions of this model can be envisaged. To date, incumbent clearing houses are relatively protected from their competitors by the existence of privileged agreements with stock markets. The scheduled termination of some of these agreements risks weakening these houses on their natural market. On one hand, they can expect to have to share their market with new incomers. On

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the other hand, a significant price drop can entail a reduction of the quality and so a vertical differentiation in terms of risks management.

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Appendices

Appendix A: Proof of lemma 1

We solve the following system of the first order conditions on the clearing houses profits :

$$\begin{cases} \frac{\partial \Pi_{X_1}}{\partial p_{x_1}} = \frac{1}{2}X(1 + p_{x_2} - 2p_{x_1}) + \frac{1}{3}B(1 - 2p_{x_1} - p_{y_1} + p_b) = 0 \\ \frac{\partial \Pi_{Y_1}}{\partial p_{y_1}} = \frac{1}{2}Y(1 + p_{y_2} - 2p_{y_1}) + \frac{1}{3}B(1 - 2p_{y_1} - p_{x_1} + p_b) = 0 \\ \frac{\partial \Pi_{XY_2}}{\partial p_{x_2}} = \frac{1}{2}X(-2p_{x_2} + 2p_{x_1}) = 0 \\ \frac{\partial \Pi_{XY_2}}{\partial p_{y_2}} = \frac{1}{2}Y(1 - 2p_{y_2} + 2p_{y_1}) = 0 \\ \frac{\partial \Pi_{XY_2}}{\partial p_b} = \frac{1}{3}B(2 - 2p_b + p_{x_1} + p_{x_2}) = 0 \end{cases} \tag{35}$$

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As indicated below, the second order conditions are verified. The problem is so globally concave :

$$\frac{\partial^2 \Pi_{X_1}}{\partial p_{x_1}^2} = -X - \frac{2}{3}B < 0 \tag{36}$$

$$\frac{\partial^2 \Pi_{Y_1}}{\partial p_{y_1}^2} = -Y - \frac{2}{3}B < 0 \tag{37}$$

Let be H_{XY_2} the Hessian matrix of the house XY_2 profit in its strategic variables :

$$H_{XY_2} = \begin{pmatrix} -X & 0 & 0 \\ 0 & -Y & 0 \\ 0 & 0 & -\frac{2}{3}B \end{pmatrix}. \tag{38}$$

We have now $\frac{\partial^2 \Pi_{XY_2}}{\partial p_{x_1}^2} < 0$. The matrix determiner $\begin{vmatrix} -X & 0 \\ 0 & -B \end{vmatrix}$ is positive. Then, the determiner of H_{XY_2} is equal to $-\frac{2}{3}XYB < 0$.

Appendix B: Proof of the banks surplus within the benchmark

On market X, the banks surplus is as follows:

$$S_X^* = \tilde{\theta}_X^* X(\phi_X - \int_0^{\tilde{\theta}_X^*} x dx - p_{x_1}^*) + \tilde{\theta}_X^* X(\phi_X - \int_{\tilde{\theta}_X^*}^1 (1-x)dx - p_{x_2}^*) = X(\phi_X - \frac{9}{8}), \tag{39}$$

Same for the other types of banks:

$$S_Y^* = \tilde{\theta}_Y^* Y(\phi_Y - \int_0^{\tilde{\theta}_Y^*} x dx - p_{y_1}^*) + \tilde{\theta}_Y^* Y(\phi_X - \int_{\tilde{\theta}_Y^*}^1 (1-x)dx - p_{y_2}^*) = Y(\phi_Y - \frac{9}{8}), \tag{40}$$

$$S_B^* = \tilde{\theta}_B^* B(\phi_X + \phi_Y - \int_0^{\tilde{\theta}_B^*} 2x dx - p_{x_1}^* - p_{y_1}^*) + \tilde{\theta}_B^* B(\phi_X + \phi_Y - \int_{\tilde{\theta}_B^*}^1 (1-x)dx - p_b^*) = B(\phi_X + \phi_Y) - \frac{59}{27}B. \tag{41}$$

So, we are getting the total surplus for the banks at the equilibrium :

$$S^* = X\phi_X + Y\phi_Y + B(\phi_X + \phi_Y) - \frac{9}{8}(X+Y) - \frac{59}{27}B. \tag{42}$$

Supposing that $\phi_X = \phi_Y = \phi$, the existence condition of this problem is that $\phi \geq \frac{243X+243Y+472B}{216(X+Y+2B)}$.

Appendix C: Proof of lemma 2

We solve the following system of the first order conditions on the profits of clearing houses :

$$\begin{cases} \frac{\partial \Pi_{X_1}}{\partial p_{x_1}} = \frac{1}{2}X(1+p_{x_2}-2p_{x_1}) = 0 \\ \frac{\partial \Pi_{X_1}}{\partial p_{b_1}} = \frac{1}{2}B(1+p_{b_2}-2p_{b_1}) = 0 \\ \frac{\partial \Pi_{Y_1}}{\partial p_{y_1}} = \frac{1}{2}Y(1+p_{y_2}-2p_{y_1}) = 0 \\ \frac{\partial \Pi_{XY_2}}{\partial p_{x_2}} = \frac{1}{2}X(1+p_{x_1}-2p_{x_2}) = 0 \\ \frac{\partial \Pi_{XY_2}}{\partial p_{y_2}} = \frac{1}{2}Y(1+p_{y_1}-2p_{y_2}) = 0 \\ \frac{\partial \Pi_{XY_2}}{\partial p_{b_2}} = \frac{1}{2}B(1+p_{b_1}-2p_{b_2}) = 0 \end{cases} \tag{43}$$

As indicated below, the second order conditions are verified. The problem is so globally concave.

Let H_{X_1} the Hessian matrix of the clearing X_1 profit in its strategic variables :

$$H_{X_1} = \begin{pmatrix} -X & 0 \\ 0 & -B \end{pmatrix}. \tag{44}$$

The determiner of this matrix is equal to$XB > 0$ and $\frac{\partial^2 \Pi_{X_1}}{\partial p_{x_1}^2} < 0$.

Let H_{XY_2} the Hessian matrix of the clearing house XY_2 profit in its strategic variables :

$$H_{XY_2} = \begin{pmatrix} -X & 0 & 0 \\ 0 & -Y & 0 \\ 0 & 0 & -\frac{2}{3}B \end{pmatrix}. \tag{45}$$

The conditions are identical to the matrix H_{X_1} and this matrix determiner is equal to $-\frac{2}{3}XYB < 0$.

Appendix D. Proof of the banks surplus in the case of simple interoperability

On market X, the banks surplus is as follows:

$$S^*_{XI} = \tilde{\theta}^*_{XI}X(\phi_X - \int_0^{\tilde{\theta}^*_{XI}} xdx - p^*_{x_1}) + \tilde{\theta}^*_{XI}X(\phi_X - \int_{\tilde{\theta}^*_{XI}}^1 (1-x)dx - p^*_{x_2}) = X(\phi_X - \frac{9}{8}). \tag{46}$$

In the same way, we obtain the surpluses of the other types of banks:

$$S^*_{YI} = Y(\phi_Y - \frac{9}{8}), \tag{47}$$

$$S^*_{BI} = B(\phi_X + \phi_Y - \frac{9}{8}). \tag{48}$$

So, we obtain the total surplus for the banks at the equilibrium:

$$S^*_I = X\phi_X + Y\phi_Y + B(\phi_X + \phi_Y) - \frac{9}{8}(X+Y+B) \tag{49}$$

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In supposing that $\phi_X = \phi_Y = \phi$, the existence condition of this problem is that $\phi \geq \frac{9}{8}\frac{X+Y+B}{X+Y+2B}$.

Appendix E. Proof of the equilibrium of double interoperability

We solve the following system of the first order conditions on the profits of clearing houses given that houses X_1 et Y_1 have a behaviour of agreement :

$$\begin{cases} \frac{\partial(\Pi_{X_1}+\Pi_{Y_1})}{\partial p_{x_1}} = \frac{1}{2}X(1+p_{x_2}-2p_{x_1}) = 0 \\ \frac{\partial(\Pi_{X_1}+\Pi_{Y_1})}{\partial p_{y_1}} = \frac{1}{2}Y(1+p_{y_2}-2p_{y_1}) = 0 \\ \frac{\partial(\Pi_{X_1}+\Pi_{Y_1})}{\partial p_{b_1}} = \frac{1}{2}B(1+p_{b_2}-2p_{b_1}) = 0 \\ \frac{\partial \Pi_{XY_2}}{\partial p_{x_2}} = \frac{1}{2}X(1+p_{x_1}-2p_{x_2}) = 0 \\ \frac{\partial \Pi_{XY_2}}{\partial p_{y_2}} = \frac{1}{2}Y(1+p_{y_1}-2p_{y_2}) = 0 \\ \frac{\partial \Pi_{XY_2}}{\partial p_{b_2}} = \frac{1}{2}B(1+p_{b_1}-2p_{b_2}) = 0 \end{cases} \tag{50}$$

As indicated below, the second order conditions are verified. The problem is so globally concave. Let $H_{X_1Y_1}$ the Hessian matrix of the sum of the houses X_1 et Y_1 profits in its strategic variables :

$$H_{X_1Y_1} = \begin{pmatrix} -X & 0 & 0 \\ 0 & -Y & 0 \\ 0 & 0 & -B \end{pmatrix}. \tag{51}$$

We have so $\frac{\partial^2 \Pi_{XY_1}}{\partial p_{x_1}^2} < 0$. The matrix determiner $\begin{vmatrix} -X & 0 \\ 0 & -Y \end{vmatrix}$ is positive.

Finally, the determiner of $H_{X_1Y_1}$ is equal to $-XYB < 0$.

Let H_{XY_2} the Hessian matrix of the clearing house XY_2 profit in its strategic variables :

$$H_{XY_2} = \begin{pmatrix} -X & 0 & 0 \\ 0 & -Y & 0 \\ 0 & 0 & -B \end{pmatrix}. \tag{52}$$

We have so $\frac{\partial^2(\Pi_{X_1}+\Pi_{Y_1})}{\partial p_{x_1}^2} < 0$. The matrix determiner $\begin{vmatrix} -X & 0 \\ 0 & -B \end{vmatrix}$ is positive. Finally, the determiner of H_{XY_2} is equal to $-XYB < 0$.

Appendix F : Proof of the banks surplus in case of double interoperability

On market X, the banks surplus is as follows :

$$S^*_{XDI} = \tilde{\theta}^*_{XDI}X(\phi_X - \int_0^{\tilde{\theta}^*_{XDI}} xdx - p^*_{x_1}) + \tilde{\theta}^*_{XDI}X(\phi_X - \int_{\tilde{\theta}^*_{XDI}}^1 (1-x)dx - p^*_{x_2}) = X(\phi_X - \frac{9}{8}). \tag{53}$$

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In the same way, we obtain the surpluses of the other types of banks :

$$S^*_{YDI} = Y(\phi_Y - \frac{9}{8}), \tag{54}$$

$$S^*_{BDI} = B(\phi_X + \phi_Y - \frac{9}{8}). \tag{55}$$

So, we obtain the total surplus for the banks at the equilibrium :

$$S^*_{DI} = X\phi_X + Y\phi_Y + B(\phi_X + \phi_Y) - \frac{9}{8}(X + Y + B) = SB^*_I \tag{56}$$

In supposing that$\phi_X = \phi_Y = \phi$, the existence condition of this problem is that $\phi \geq \frac{9}{8}\frac{X+Y+B}{X+Y+2B}$.

Appendix G : Proof of the equilibrium of merger

We solve the following system of the first order conditions on the profits of clearing houses:

$$\begin{cases} \frac{\partial \Pi_{X_1Y_1}}{\partial p_{x_1}} = \frac{1}{2}X(1 + p_{x_2} - 2p_{x_1}) = 0 \\ \frac{\partial \Pi_{X_1Y_1}}{\partial p_{y_1}} = \frac{1}{2}Y(1 + p_{y_2} - 2p_{y_1}) = 0 \\ \frac{\partial \Pi_{X_1Y_1}}{\partial p_{b_1}} = \frac{1}{2}B(1 + p_{b_2} - 2p_{b_1}) = 0 \\ \frac{\partial \Pi_{XY_2}}{\partial p_{x_2}} = \frac{1}{2}X(1 + p_{x_1} - 2p_{x_2}) = 0 \\ \frac{\partial \Pi_{XY_2}}{\partial p_{y_2}} = \frac{1}{2}Y(1 + p_{y_1} - 2p_{y_2}) = 0 \\ \frac{\partial \Pi_{XY_2}}{\partial p_{b_2}} = \frac{1}{2}B(1 + p_{b_1} - 2p_{b_2}) = 0 \end{cases} \tag{57}$$

As indicated below, the second order conditions are verified. The problem is so globally concave. Let $H_{X_1Y_1}$ the Hessian matrix of the clearing X_1Y_1 profit in its strategic variables :

$$H_{X_1Y_1} = \begin{pmatrix} -X & 0 & 0 \\ 0 & -Y & 0 \\ 0 & 0 & -B \end{pmatrix}. \tag{58}$$

We have so $\frac{\partial^2 \Pi_{X_1Y_1}}{\partial p^2_{x_1}} < 0$. The matrix determiner $\begin{vmatrix} -X & 0 \\ 0 & -Y \end{vmatrix}$ is positive. Finally, the determiner of $H_{X_1Y_1}$ is equal to $-XYB < 0$.

Let H_{XY_2} the Hessian matrix of the clearing house profit in its strategic variables :

$$H_{XY_2} = \begin{pmatrix} -X & 0 & 0 \\ 0 & -Y & 0 \\ 0 & 0 & -B \end{pmatrix}. \tag{59}$$

We have so $\frac{\partial^2 \Pi_{XY_2}}{\partial p^2_{x_1}} < 0$. The matrix determiner $\begin{vmatrix} -X & 0 \\ 0 & -B \end{vmatrix}$ is positive. Finally, the determiner of

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H_{XY_2} is equal to $-XYB < 0$.

Appendix H. Proof of the banks surplus in case of merger

On market X, the banks surplus is as follows:

$$S^*_{XM} = \tilde{\theta}^*_{XM} X(\phi_X - \int_0^{\tilde{\theta}^*_{XM}} x dx - p^*_{x_1}) + \tilde{\theta}^*_{XM} X(\phi_X - \int_{\tilde{\theta}^*_{XM}}^1 (1-x)dx - p^*_{x_2}) = X(\phi_X - \frac{9}{8}). \quad (60)$$

In the same way, we obtain the surpluses of the other types of banks :

$$S^*_{YM} = Y(\phi_Y - \frac{9}{8}), \quad (61)$$

$$S^*_{BM} = B(\phi_X + \phi_Y - \frac{9}{8}). \quad (62)$$

So, we obtain the total surplus for the banks at the equilibrium :

$$S^*_M = X\phi_X + Y\phi_Y + B(\phi_X + \phi_Y) - \frac{9}{8}(X + Y + B) = SB^*_I = SB^*_{DI} \quad (63)$$

In supposing that $\phi_X = \phi_Y = \phi$, the existence condition of this problem is that $\phi \geq \frac{9}{8}\frac{X+Y+B}{X+Y+2B}$.

Appendix I :

If $\underline{F_1 < 7}$, the matrix of earnings is as follows :

$X1/Y1$	*Status quo*	Interoperability	Merger
Status quo	$31 - F_1/31 - F_1$	$7 - F_1/43 - F_1 - f$	$31 - F_1/31 - F_1$
Interoperability	$43 - F_1 - f/7 - F_1$	$25 - F_1 - f/25 - F_1 - f$	$43 - F_1 - f/7 - F_1$
Merger	$31 - F_1/31 - F_1$	$7 - F_1/43 - F_1 - f$	$25 - \frac{1}{2}F_M/25 - \frac{1}{2}F_M$

In this first case, it is supposed that $F_1 < 7$, so that all the issues of the game are practicable. The profit of merger is always lower than the benefit of the benchmark corresponding to the choices of the status quo by the one or both incumbent clearing houses X and Y. In fact, in order to have the profit of merger upper than the benefit of the benchmark, it is necessary that $31 - F_1 < 25 - \frac{F_M}{2}$ or more that $F_1 > \frac{F_M}{2} + 6$. As $F_1 < 7$, this is possible only if $F_M < 2$. But we know that $F_M > F_1$ what contradicts the initial disparity. So, this game accepts three equilibriums: {status quo / status quo; status quo / merger; merger / status quo}. Whatever is the selected equilibrium, we have so a situation of status quo.

If $\underline{7 < F_1 < 25}$ and$\underline{F_1 + f < 25}$, the matrix of earnings is as follows :

$X1/Y1$	*Status quo*	Interoperability	Merger
Status quo	$31 - F_1/31 - F_1$	$0/50 - 2F_1$	$31 - F_1/31 - F_1$
Interoperability	$50 - 2F_1/0$	$25 - F_1 - f/25 - F_1 - f$	$50 - 2F_1/0$
Merger	$31 - F_1/31 - F_1$	$0/50 - 2F_1$	$25 - \frac{1}{2}F_M/25 - \frac{1}{2}F_M$

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In this second case, the clearing house acceding to a request of interoperability goes out of the market. Nevertheless, the merger and the double interoperability remain viable exits for both clearing houses. Therefore, we keep both following limitations on the fixed costs of the incumbent houses: $F_1 > 7$ et $F_1 + f < 25$. If an agreement of simple interoperability emerges, the clearing house having asked for the interoperability gets back all the market shares of the outgoing incumbent house. If $F_1 > 12$, the profit of merger is upper than the benefit of the benchmark. In fact, an upper profit of merger for the benefit of the benchmark leads that $31 - F_1 < 25 - \frac{F_M}{2}$ or still that $F_1 > 6 + \frac{F_M}{2}$. This possibility is conceivable if $F_1 > 12$. This new condition allows to respect the disparity $F_1 < F_M < 2F_1$. The costs savings generated by the merger are quite strong, this allowing to obtain two different equilibriums : {*status quo* / *status quo* ; merger / merger}. The equilibrium of merger is Pareto dominant, allowing selecting it. If on the contrary $F_1 < 12$, the equilibrium is the *status quo*.

If $\underline{12,5 < F_1 < 25}$ and $\underline{F_1 + f > 25}$, the matrix of earnings is as follows :

$X1/Y1$	*Status quo*	Interoperability	Merger
Status quo	$31 - F_1/31 - F_1$	$0/50 - 2F_1$	$31 - F_1/31 - F_1$
Interoperability	$50 - 2F_1/0$	$0/0$	$50 - 2F_1/0$
Merger	$31 - F_1/31 - F_1$	$0/50 - 2F_1$	$25 - \frac{1}{2}F_M/25 - \frac{1}{2}F_M$

In this third case, the double interoperability is not viable any more unlike the merger. We have for conditions that $7 < F_1 < 25$ and that $F_1 + f > 25$. The second condition restricts de facto the first one by imposing that $F_1 > 12,5$ because $f < F_1$, where from the condition $F_1 > 12,5$. An agreement of simple interoperability makes the clearing house acceding to a request of interoperability getting out of the market. The profits of the merger are superior to those of the benchmark if $F_1 > \frac{F_M}{2} + 6$. In fact, an upper profit of merger for the benefit of the benchmark involves that 31 $31 - F_1 > 25 - F_M$, or more that $F_1 > \frac{F_M}{2} + 6$. This involves that $F_1 < F_M < 2F_1 - 12$. This possibility is very conceivable if $F_1 > 12,5$. In that case, the gains in fixed costs are rather strong to bring to the foreground two different equilibriums. It is the following whole strategy: {status quo / status quo; merger / merger}. Following the example of the previous case, we select the equilibrium of merger because, from the point of view of both clearing houses, it is "Pareto dominant". If on the contrary $F_1 > \frac{F_M}{2} + 6$, the equilibrium corresponds to the benchmark.

If $\underline{25 < F_1 < 31}$, the matrix of earnings is as follows :

$X1/Y1$	*Status quo*	Merger
Status quo	$31 - F_1/31 - F_1$	$31 - F_1/31 - F_1$
Merger	$31 - F_1/31 - F_1$	$25 - \frac{1}{2}F_M/25 - \frac{1}{2}F_M$

This fourth case excludes now all the possibilities of interoperability but keeps opened a possible merger. The strategies of interoperability are really excluded because they all succeed in the monopolization of the market by the Pan European clearing house. If the merger generates enough

savings of fixed costs to be preferred to the status quo, i.e. if $F_1 > \frac{F_M}{2} + 6$, we obtain two different equilibriums representing the following whole strategy {status quo / status quo; merger / merger}. This condition moreover involves that $F_M < 50$. Following the example of the previous case, we select the "Pareto Dominant" equilibrium corresponding to the merger. If on the contrary, $F_1 > \frac{F_M}{2} + 6$, the equilibrium corresponds to the *status quo*.

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