

The Economics of Debt Clearing Mechanisms

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Abstract

We examine the evolution of decentralized clearinghouse mechanisms from the 13th to the 18th century; in particular, we explore the clearing of non- or limited-tradable debts like bills of exchange. We construct a theoretical model of these clearinghouse mechanisms, similar to the models in the theoretical matching literature, and show that specific decentralized multilateral clearing algorithms known as *rescontre*, *skontrieren* or *virement des parties* used by merchants were efficient in specific historical contexts. We can explain both the evolutionary self-organizing emergence of late medieval and early modern fairs, and its robustness during the 17th and 18th century.

JEL classification: C78; D02; N23

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1 Introduction

Late medieval Europe was characterized by a revival of trade among the regions of the continent and the emergence of complementary trade-related innovations, a time commonly characterized as the Commercial Revolution (Lopez 1976). Merchants travelled with their goods from one city to the next and many fair locations emerged where traders from different parts of Europe met (Verlinden 1971; Blockmans 1996). An important step in the evolution of trade was the separation of the quid and quo (Greif 2002, 2006). This means that the payment for purchased goods no longer took place at the same time and place but at the next fair or market, either at the same or at a different location. Alongside this development appeared financial instruments like the cambium, letter obligatory or the bill of exchange, which were orders or promises of future payment at a specific place and time, typically during the payment days at the end of a fair, by the drawer or the representative or a banker of the drawer (Goldschmidt 1891; Schappas 1892; de Roover 1953). This was very useful for a merchant, since he could negotiate a time and place when and where he expected to be liquid again, for example after the successful trading of goods or when he expected to cash in bills himself. Cashless payment was a good alternative to carrying heavy gold or silver coins along dangerous trading routes. In addition, it limited the dependency of merchants on the currency policies of local dukes. The only downside was the limited tradability of the instruments (Usher 1943; Van der Wee 1963; North 1981; Munro 1994; for a discussion see Boerner and Ritschl 2006, 2009).

As a consequence of this development, a need for the settlement of liabilities, typically at the end of a fair or market period, arose. Merchants and merchant bankers met to settle bills of exchange and other liabilities to balance their positions. At fairs and market locations, payment days evolved and during the 16th century even exclusive clearing fairs in Besancon and later Piacenza and Novi were established where mainly bills of exchange were settled from all over Europe (Endemann 1885; Neuhaus 1892; Ehrenberg 1896; Vigne 1903; Haristoy 1906; Prausnitz 1928; Carande 1943; Lapeyre 1955; Da Silva 1969; Gascon 1971; Boyer-Xambeu et. al.1986; Denzel 1994, 2009). At these late medieval and early modern markets and fairs a specific decentralized multilateral clearing algorithm to offset non-tradable credits with debts was developed. This netting procedure is known in the sources as *rescontrire*, *rescontre*,

skontrieren, or vivre compte / des parties.

In a nutshell, the procedure worked as follows: all merchants met on fixed days at the end of the market or fair, everybody revealed his debtors, and creditors had to confirm their liabilities. Then, merchants tried to offset credits with debts in a decentralized searching and matching way: in the first step they cancelled reciprocal debts, in the second step they used clearing cycles, and, in the third and final step, they used clearing chains. At the end, still unbalanced positions had to be paid in cash or new bills had to be drawn.

This clearing mechanism developed at late medieval fairs and was perfected at the financial fairs of the late 16th and early 17th century, where it developed into a formal procedure embedded in a legal framework. This was the dominant debt-clearing mechanism in Europe's most important trade centres: Germany, Italy, France, the Low Countries and Spain. These markets and fairs not only built the central nodes of European finance and trade but also acquired capital to finance trade with the New World. (Ehrenberg 1896, Da Silva 1969, Boyer-Xambeu et. al. 1986; van der Wee 1993, Pezzolo and Tattaro 2008, Denzel 2009).

It waned in importance when the first exchange banks took over the clearing business and general endorsement of bills of exchange during the 17th century (Schneider 1989; Brübach 1994). Nevertheless, there is strong evidence that this decentralized procedure was still in use at many markets and fairs during the 17th and 18th century. In addition, traders who worked under the first stock exchange markets used the same technique to offset payments for stocks or future contracts in cities like Amsterdam and London (Parker 1974; Gelderbloom and Jonker 2005). After the establishment of the London Clearing Club in 1775, banks began settling their liabilities in a similar way (Seyd 1872). Thus, this decentralized multilateral clearing algorithm was the backbone of financial clearing during more than 500 years pre-industrial growth in Europe.

The research questions of interest are 1) why such clearing mechanisms came into existence and 2) why they were so successful for several hundred years. Of course, these clearing mechanisms reduced the need for cash. However, these mechanisms had to have achieved a high clearing rate. On the one hand, merchant books and contemporary witnesses document that the mechanism was quite successful. On the other hand, legal documents give evidence that merchants were more or less forced to participate in these mechanisms and were not allowed to pay in cash. In addition,

there is evidence that merchants had preferences over the choice of their clearing partners and the clearing order.

Not much attention has been paid to the microstructure of this clearing mechanism so far. Legal and economic historians focused on the description, not on institutional analysis. These authors did not come to a clear conclusion about the clearing efficiency. They recognised the use of the clearing technology for cashless payment all over Europe to generate credit and solve problems of money shortage (Neuhaus 1892; Ehrenberg 1896; Boyer-Xambieu 1986; Brübach 1986; M. North. 1996; Denzel 2005, 2009); however, a valuation of the clearing mechanism has been missing or efficiency has been assumed simply because of the success of the mechanism. Alternatively, it has been argued that the mechanism was inefficient because the clearing was decentralized and looked rather complicated.

In contrast to these approaches we use a theory guided approach (Greif 1993, 2006, Greif et al. 1994) to study the efficiency of the settlement mechanism. We analyze the main characteristics of the clearing procedure and develop a theoretical model of the mechanism and proceed to analyze its properties. We examine the matching and clearing of non-tradable assets which are complementary in utility to each other when matched efficiently. This modelling goes back to allocation methods using the successive removal of cycles, which were first proposed by Shapley and Scarf (1974) for the housing allocation problem and subsequently studied by researchers such as Abdulkadiroğlu and Sönmez (2002), and Ehlers (2002). Recently, Alvin Roth et al. (2004; 2005) applied these techniques to the kidney exchange problem.

We show that the functioning of these mechanisms depends on the balance of positions (credits and debts) of merchants *ex ante* and the use of clearing cycles or clearing chains. If positions are balanced, then efficient clearing is always achievable with clearing cycles and also with clearing chains. If positions are unbalanced, and only cycles are used, then depending on the ordering of the cycles different levels of clearing efficiencies can be achieved, and some agents may have both credits and debts at the end. However, if chains are used, each merchant will be reduced to his net position, but depending on the clearing order the distribution of debt transfers among merchants differs *ex post*. These properties can lead to strategic behaviour of merchants in the form of strategic misrepresentation of information and an unwillingness to participate in specific cycles or chains. This can reduce the efficiency of the clearing.

Consequently, the clearing efficiency depends on the willingness of the merchants to participate in the clearing mechanism in general and the willingness to participate in specific cycles or chains in particular, and these both depend on the expected balance of the positions and the enforcement of unbalanced positions ex post. This enforcement can be achieved based on reputation effects or on legal enforcement. Finally, in unbalanced positions, the liquidity of the market after the mutual clearing has been done is important; the ability to draw new bills on future clearing locations increases the willingness to participate ex ante although the merchants expect that positions will be unbalanced ex post. Thus, if merchants are willing to participate in the mechanism all gross positions can be cleared to the net positions by a decentralized search and matching mechanism independent of the ordering of the use of bilateral clearing, cycles or chains.

These results can explain the self-organizing emergence of the mechanism during the late Middle Ages in fairs and financial markets and why during the early modern period a specific form of this mechanism embedded in the legal framework evolved all over Europe. In addition, it can be shown why the mechanism was generally robust and only vulnerable in cases of strong economic shocks or of political abuse. This made it difficult for competing institutions such as the public exchange banks to take over the clearing business.

The remainder of the paper is structured the following way: section 2 examines the history of the mechanism, from its early development in the late Middle Ages to its perfection in the 16th and 17th century. In addition, the role of exchange banks, endorsement of bills of exchange, the emergence of the mechanism on the first stock exchanges, and the use of the mechanism in form of clearing clubs among banks are discussed. Section 3 studies the mechanism more formally. A theoretical game model is set up which analyzes the algorithm; the equilibrium outcomes are discussed. In section 4 the theoretical predicted outcomes are discussed in their historical context. Both the successes and the vulnerabilities of the mechanism are elaborated in detail. Section 5 concludes. The proofs of propositions in Section 3 may be found in the Appendix.

2 Historical Development

Section 2 gives a comprehensive historical analysis of the mechanism: Section 2.1 describes the early development until the 16th century, and the formation of the formal procedure and legislation during the 16th and early 17th century, section 2.2 the rules and customary practices, section 2.3 the further development, and finally section 2.4 an evaluation of the efficiency based on the descriptive source analysis.

2.1 Early Development and the formation of a formal procedure

The evidence of the use of such clearing mechanisms can be traced to the late Middle Ages. The first documents do not inform us about a detailed structure or procedure of the clearing process, but just indicate its existence and probably its common use. The earliest sources are from Champagne fairs by the end of the 12th and beginning of the 13th century (Anschütz 1887, pp. 108f.; Haristoy 1906, pp. 284-88; Face 1957) The usage of mutual settlement on the central fair locations of Europe can be again documented from the Late 14th century and 15th century onwards: Evidence of the use in Germany in Frankfurt, Brunswick, and later Leipzig (Orth 1765, p. 446, Wolf 1967, p. 205f., Bücher 1915, p.212f. Brübach 1994, p.284, 307), Lyon in France (Ehrenberg 1886, pp. 74-8; Vinge 1903, pp. 110ff.; Haristoy 1906, pp 296-301; Bresard 1914, Gascon 1971, pp. 242-8; Boyer-Xambeu 1986, pp. 189-198), in the Netherlands in Antwerp and Bergen op Zoom (Ehrenberg 1896, pp. 10-13; van der Wee 1993, pp.151-158), and in Spain on the Castilian fairs of Medina del Campo (Rodriguez and Fernandez 1903, pp. 642f.; Carande 1943, pp. 195-234.; Martin 1965, pp. LXXXII-CIII; Vasquez de Prada 1991, pp. 117f). Early evidence from the 15th and 16th century can also be found in Mediterranean merchant cities with permanent wholesaler markets and finance locations such as Barcelona, Genoa, Naples, and Venice. (Capmany 1792, p. 167; Lattes 1869, pp 72; Ajello 1884, pp. 728ff.; Prausnitz 1928, p. 11)

The common use of this clearing technology in many merchant cities and fair locations during the 15th and 16th century was documented by the first regulations which describe the clearing procedure in more detail by the end of the 16th century of the clearing fairs of Piacenza. These regulations from 1597 were taken over from the

former clearing fairs of Besancon and are named as the orders of Besancon. This was the first exclusive clearing fair and was founded by the Genoese in 1537 to compete and replace the clearing fairs of Lyon, which in turn goes back to the second half of the 15th century. Because of this it has been argued that the clearing procedure described in the statutes of Besancon goes back to the customary practice applied by merchant bankers in Lyon.¹ These orders from Besancon have been handed over by Raphael Turri in 1642, who describes the clearing process in detail by himself. In addition, Peri 1638 and Sacchia 1645 bring in further descriptions of the clearing process (Neuhaus 1892; Endemann 1885 174ff.; Ehrenberg 1896, pp. 230-6; Prausnitz 1928; Da Silva 1969, chapter 2).

The regulations can be seen as a blueprint of the procedures that can be found in many exchange laws during the 17th and 18th century in Europe. Similar procedures can be found in the fairs in Italy such as Novi, Bozen and Verona, which replaced Piacenza (Da Silva 1969; Denzel 2005, 2009). In France, Lyon kept on as the clearing centre for bills and other obligations, where the procedures were codified in detail in 1667 based on earlier attempts starting in 1642 (Haristoy 1906, pp. 303ff; Vigne 1903, pp. 118ff.). During the same time Frankfurt, the most important fair location and finance centre in Germany, produced its first more detailed exchange law. This was inspired by the codification in Lyon. Whereas Frankfurt had already a long tradition of using this clearing technique which goes back to the late 14th century, clearing regulations could only be found in 1578, 1611 and finally a more detailed version in 1666. (Brübach, pp. 169-76). Other important clearing locations with regulations about the mechanism were Bruinswick 1686, 1715 and Leipzig 1682, 1711.² Further evidence is available from merchant cities as Augsburg, Breslau, Nuremberg and others (Brübach 1994, p. 318; Neuhaus 1892, p. 11).³

¹This argument goes back to Endemann 1886, p. 174. Customary practices of the 16th century Lyon fair have been handed over by Fabiano 1556, Trenchant 1556, de Savonne 1567; de Rubys 1604. Later authors are Boyer 1627 and Clerac 1656. See Vigne 1903, pp. 118-128. Haristoy 1906, pp. 296-301; Bresard 1914; Gascon 1971, pp.242-8.

²Very short regulations for Leipzig existed in 1621 and 1676. See Hasse 1886, pp 277f.; Neuhaus 1892, p. 11; Brübach 1994, pp. 310ff.

³Beside the exchange law, contemporary writers like Raumburger (1723) and Riccius (1783) draw on more evidence on the procedure on these places.

2.2 Regulations and Customary Practices

Clearing took place about four times a year. This goes back to the tradition that fairs were held quarterly and at the end of each fair, a financial clearing was set.⁴ This pattern can be documented for Lyon, the Brabant fairs with Antwerp and Bergen, the Castilian fairs and all the Italian and most of the German fairs (Ehrenberg 1892, Da Silva 1969; van der Wee; Boyer-Xambeu et al.1986). In cities in which fairs became permanent markets or when financial clearing was separated from the goods trading, the frequency was increased to monthly or even weekly meetings during the 17th and 18th century. This can be documented in the regulations of Frankfurt 1776 and Leipzig 1688, or in Augsburg where only a financial exchange was implemented (Neuhaus 1892, p. 11; Prausnitz 1928, p. 22; Brübach 1994, p. 175, 318).⁵ These clearing meetings lasted several days. In Besancon for example it took eight days, always in a fixed ordering.

In most regulations there were no restrictions on participation. The clearing was open to everybody, however de Turri reports that in Besancon participants were merchant bankers and only they had the right to participate (Endemann 1889; p. 174, Prausnitz 1928, p. 17). However Scaccia and Peri write that whoever wanted to participate had to pay a deposit (Endemann 1889, p. 174; Neuhaus 1892, p. 13; Ehrenberg 1896, p.231). Sometimes merchants attending a fair were forced to take part in the clearing procedure. This was stipulated in the regulations of Bozen and Leipzig (Neuhaus 1892, p. 31, 39).⁶ These rules excluded cash payments or agreements about later payments *ex ante* by merchants who had not taken part in the mutual clearing procedure. Under the rules of Besancon, merchants who wanted to be paid in cash had to announce this at the beginning and had to seal the money (Ehrenberg 1892, p. 235; Prausnitz 1928; Neuhaus 1892). However de Turri, Scaccia, and Azorius, another writer from 1625, report that merchants had preferences for mutual clearing and were worried about receiving their payments in cash (Neuhaus 1892, p.19, 21; Endemann 1889, p. 179).

The clearing procedure worked the following way: merchant bankers met with their ledgers (*scartefacci*). In early Besancon there were at least 50-60 bankers. In

⁴For the typical fairs customs, see Verlinden 1971.

⁵Permanent marketplaces document weekly meetings earlier on; for example sources from Naples indicate weekly meetings as early as the 16th century: See Ajello 1884, pp. 728ff.

⁶See also the report by Raumburger (1723).

Piacenza there were about 110 (Ehrenberg 1892, p.229). Merchants who wanted to participate had to be present or have an official representative. This can be found in the statutes of Besancon and most of the later regulations during the 17th and 18th century (Endemann 1885, p. 175 Brübach 1994, pp. 306f.; Neuhaus 1892, p. 30; Haristoy 1906, p. 304f). Then, all creditors revealed their debtors.⁷ The debtors had to confirm or reject the debts.⁸ In the next step, each banker had to create a balance sheet with all the accepted claims, which had to be submitted in Besancon where officials would check the general balance.⁹ This practice cannot be documented for other fairs later on. Only accepted bills were taken in and were valid for the later mutual netting procedure. Rejected bills were discussed in front of the fair court and settled later.¹⁰ This regulation was in use also in all other fairs (Endemann 1885, p. 175ff; Prausnitz 1928, p. 17; Brübach 1994, p. 309). De Turri writes that not all bankers were honest and were willing to go in front of the court and settle these bills only later (Endemann 1885, p. 177).

In the next step the exchange rates for the bills were fixed in an official accounting currency. This was done by a group of bankers from different regions who had participated in the clearing process. On the Genoese fairs they came only from different regions in Italy (Endemann 1885, p. 179f.; Ehrenberg 1896, p. 232), in Lyon from France, Germany and Italy (Gascon 1971, pp. 244f.).¹¹ The regulations of Besancon state that exchange rates should be reasonable. However based on these rates, other market prices were negotiated ex post (Ehrenberg 1896, p. 234f.). Having different participating representatives was also typical for the later regulations. In Frankfurt, where the fixing of the exchange rate can be documented from 1585 onwards, in 1625 a legislation was passed after some bankers at previous fair meetings tried to manipulate exchange rates in their favor; it was stated that the exchange rates were set up

⁷It is not clear if this was all public or happened in a bilateral way: see Ehrenberg 1896, p. 234; Martens 1794, p. 16 Neuhaus 1892, p. 8; Prausnitz 1928, p. 17; Endemann 1886, p. 176; Brübach 1994, p. 175.

⁸See the reports by Scaccia and de Turri, see Endemann 1886, p. 176. For the same practice already in use in Lyon earlier on see Gascon 1971, pp. 243f. and later on see Haristoy 1906, p. 304, in Frankfurt, Brunswick and Leipzig fairs. See Brübach 1994, p. 310.

⁹This was reported by de Turri, Peri, and Scaccia. See Endemann 1886, p. 177, Ehrenberg 1896, p. 234.

¹⁰The rejection of bills can already be documented for fairs of Lyon during the second half of the 15th century. See Haristoy 1906 pp. 297f.

¹¹De Rubys 1604 reports this procedure already for the Lyon fairs during the 16th century. See Vigne 1903, p. 121.

by local exchange brokers and merchant bankers from different regions (Ehrenberg 1896, pp. 246f. Brübach 1994, p. 287, 311ff.).

In the next step, merchants started the actual clearing process sometimes with the help of brokers.¹² This process was organized as a decentralized searching and matching. The codified legal rules in various cities are rather cryptic in describing the process.¹³ However, contemporary witnesses give a very lively picture of merchant bankers who were in search of finding clearing partners during the clearing time.¹⁴ Only in Lyon during the 15th and 16th century was the clearing done by two representatives of the official authorities (Ehrenberg 1896, p. 76). The decentralized clearing algorithm worked the following way. First merchant bankers offset their position in a reciprocal way. So if merchant banker A owed B and B at the same time owed A, the common amount could be directly cancelled out.¹⁵ In the next step merchants tried to find clearing cycles and clearing chains. In a clearing cycle, for example, A owed B, B owed C, and C owed A a certain amount of money. The common amount then could also be cancelled.¹⁶ In contrast in a clearing chain, where A owed B and B owed C, only B could clear his debts and the amount that could be cancelled out had to be transferred into a new debt relationship between A and C. These clearing mechanisms could easily include five or six parties (Orth 1765, p. 481, p. E.B.A. 1773, p. 209). This clearing process was repeated again and again. For example C could use the transferred debt in the chain to bring it into another clearing chain or cycle. The sequential clearing can be documented in the ledger by Masse in 1611 (Brübach 1994, pp. 305f.). The clearing algorithm lasted until the clearing time came to an end or no merchant could find another clearing partner since everybody had reached his net position. In the exchange regulations, differentiated rules arose about the constraints on participation in the clearing mechanism. In general, the rules gave the merchants the freedom to choose the clearing cycle or chains in which they wanted to partici-

¹²The help of brokers can be documented for the German fairs in Frankfurt, Brunswick and Leipzig. See Brübach 1994, p. 316f.

¹³For example see the regulations of Frankfurt 1611; Brunswick 1686, 1715; Leipzig 1688, Breslau 1742; see Prausnitz 1928, p. 23; Brübach 1994, p. 170.

¹⁴Evidence can be found in de Turri and Scaccia for the earlier period. For the late 17th and 18th century see Raumburger, Marberger, Riccius, Zipffel. On this see Endemann 1886, p. 178; Prausnitz 1928, pp.17, 23; Neuhaus 1892, p.9.

¹⁵Scaccia and de Turri report this for the Genoese fairs. See Neuhaus 1892, p. 8, Prausnitz 1928, p. 17, Endemann 1882, p. 177)

¹⁶For the Genovese fairs Peri gives an example. See Ehrenberg 1896, pp.235f. For later fairs see for example descriptions by Koenig and Riccius. See Prausnitz 1928 p. 23; Neuhaus 1892, p. 35.

pate. de Turri mentions this for the early practice. In addition, we can find the clause that everybody needs to agree to the specific clearing group in most of the exchange laws from the 17th century.¹⁷ All these sources imply preferences of merchants over participation in different clearing cycles or chains. A writer of a merchant handbook in 1773 reports on the rationale behind this. The author writes “you need to be careful not replacing a good debtor with a bad debtor” (E.B.A. 1773, p. 112). Another regulation that indicates different preferences over the order of clearing procedures is legislation from Frankfurt in 1666 where bankers can first offset their liabilities before those of the customers that they represent (Brübach 1994, p. 176).

After the mutual netting was finished, merchants had to check if they still had outstanding credits or debts. All mutual settlements had to have been written in their *scartefacci* and having all participants do this made the clearing official.¹⁸ In general all transfers made by the mechanism were final. This meant if a debtor was transferred to a new creditor, the old creditor was no longer liable.¹⁹ Only in Besancon was it customary practice that everybody within a clearing chain or cycle was collectively liable.²⁰ Legislation ensured that the payment of debts through the clearing mechanism had the same legal status as paying cash.²¹ Even when it turned out *ex post* that one merchant was bankrupt, priority was given to the debts that were settled by the mechanism.²² Factually, this meant that the payment could not be reversed. This way the mechanism was protected from an *ex post* unravelling of the settled debts.

In the next step the remaining debts must would be settled. Controversial bills

¹⁷See for example the exchange rules from Frankfurt from 1666, Leipziger exchange orders 1688, Prussian exchange orders 1684, the orders of Bozen 1634, Brunswick 1715, Augsburg 1716 or the descriptions by Raumburger and Marberger, Riccius. See Neuhaus 1892, p. 29; Prausnitz 1928, p. 22.

¹⁸de Turri mentions this regulation and for later fairs also Koenigk, Raumberger, Marberger, see Prausnitz 1928, p. 17f. The regulations can be found in the statutes from Lyon 1667, Leipzig 1688, 1715, Breslau, Augsburg, Bozen: See Neuhaus 1892, p. 12, 31, 38; Prausnitz 1928, p. 17f., 23; Brübach 1994, p. 314f.

¹⁹For example see the clauses from Frankfurt 1666, Leipzig 1688, Breslau, Brunswick 1686, 1715 or reports by Riccius, Marberger, and Koenigk. See Prausnitz 1928, p. 24.

²⁰Contemporary witnesses Fabiani and Merenda inform us about that: Ehrenberg 1896, pp. 235f.; Neuhaus 1892 p. 40; Brübach 1994, p. 318.

²¹For example see the exchange orders of Frankfurt 1611, for 1666; Frankfurt 1666, Lyon 1667, Bozen 1634, Brunswick 1686, Leipzig 1688 or the contemporary witnesses Franck and Phoosen: Neuhaus 1892, p. 40; Brübach 1994, p. 171, 374.

²²See the Besancon regulations, the Statuti di Genoa 1589, Lyon 1667, Leipzig 1688, the Frankfurt legislation 1611, 1666: Neuhaus 1892 p. 8, 40; Brübach 1994, p. 171, 309.

which had been rejected by the debtors were judged by the local court (Ehrenberg 1896, p.236). The payment of outstanding debts could be in cash or by drawing new bills with promises on future payments within a fixed period.²³ In Augsburg 1778 it was forbidden to draw new bills on one's own name; only cash was allowed (Neuhaus, p. 32). Strict regulations were applied in case a debtor did not offset the outstanding debts by the end of the clearing days: Scaccia and de Turri wrote that participants who did not pay were excluded and declared bankrupt (Endemann 1886, p. 178; Neuhaus 1892, p. 9, Prausnitz 1928, p. 19).²⁴ Because of this, Scaccia concluded that merchant bankers with positive positions could easily find new debtors for their money (Endemann 1886, p. 175).

By the end of the Besancon fair a general balance was produced by the officials to control the clearing. However such a general balance was not in use on other clearing locations (Endemann 1886 p. 177; Biener 1859 p. 50).

2.3 Further Development: Exchange Banks, Endorsement, Stock Exchange and Clearing clubs

From the late Middle Ages there were attempts to establish public exchange banks, whose major task was to serve as clearing houses. This goes back to the first efforts in Venice during the 14th and 15th century with the implementation in 1578 of the Rialto Bank and even earlier by the establishment of exchange banks in several towns in Spain; the first was in Barcelona in 1401 (Usher 1943; Braudel 1966; Lane and Mueller 1985). The exclusive right was given to most of these banks to handle the exchange business. However from the fragmented data we possess we know that merchants were not interested in using these centralized institutions to balance their positions. After the founding of the bank in Venice, in 1593 a regulation was passed which forbade the use of the *rescontre* technique; all bills had to be brought to the Bank. This regulation was later rescinded and decentralized clearing was allowed again (Lattes 1869, pp. 170f.). North of the Alps, efforts to install public clearing

²³See the statutes of Besancon and Frankfurt 1666, and the contemporary witnesses de Turri,

Rauburger and Franck: Endemann 1886, p. 178; Neuhaus 1892, p. 8, Biener 1859, p. 47; Prausnitz 1928, p. 18 u. 30; Brübach, p. 175f.

²⁴This practice was also already known in Lyon. See Vigne 1904, p. 126; Haristoy 1906, p. 300. In the regulations from 1667 in addition strict payment periods were fixed. See Hairstoy 1906, pp. 305f.

locations did not start until the beginning of the 17th century. The first bank was the Wisselbank of Amsterdam in 1609 (Van Dillen 1934; van der Wee 1977; de Vries and van der Woude 1997), which was a copy of the bank in Venice. More banks in the Netherlands were established during the 17th century, as well as Germany in Hamburg in 1619 and Nuremberg in 1621 (Sieveking 1934; Fuchs 1954). The success of these institutions was rather mixed. Whereas the Amsterdam exchange bank was a big success as a multifunctional institution, its role as exclusive clearing bank had to be legally enforced again and again. Even when the service was inexpensive or until 1683 free, merchants were not willing to use the institution. (van Dillen 1964, p.398; Sneller 1940, pp. 157-160) When the bank started its activities, private cashiers were forbidden to conduct the clearing business, but by 1621 the decision was reversed. In 1700 merchants were forced up to an amount of 600 and later 300 guilders to use the bank (van Velden 1933). In Hamburg in 1693 they were forced to use the bank for amounts higher than 400 marks. Merchants were not allowed to use the direct clearing procedure (Prausnitz 1928, p. 26). In Nuremberg, bank orders from 1654 and 1721 inform us that merchants were not allowed to use the Skontration to settle their bills, but had to bring them to the exchange bank. In addition, the orders from 1654 indicate that merchants were only willing to hand in the bills which they could not clear easily or that were unbalanced positions (Neuhaus 1992, p. 12; Prausnitz, p. 1928). However, the decentralized clearing was again allowed later. In important clearing locations such as Frankfurt or Leipzig no clearing banks were introduced, but merchant bankers relied on the decentralized practice in use. A similar story can be told for Lyon, France's main clearing location, where several efforts to install a central bank before the 18th century failed (Velde 2009). One of the reasons was a lack of trust in the activities of the bank. This can also be documented in the case of the banks of Nuremberg (Fuchs 1954, pp. 55-58).

Another important innovation which influenced the Skontration was the more frequent use of the endorsement of bills during the 16th and 17th century. Tradability of bills goes back to the late Middle Ages and can be documented for the 14th century (Munro 1994; Opitz 1967, van der Wee 1993). Thus, it was quite natural for the decentralized clearing locations to be confronted with transferred bills. The reaction to these bills was different from place to place. In Antwerp, with the growth of economic activities during the early 16th century, the transfer of financial instruments became standard and the court confirmed the use of transferable bills several times

during the late 16th and early 17th century (van der Wee 1977, pp. 149-63). In Frankfurt, legislation went a different way (Schneider1991, Brübach 1994, p.171-4). The court declared, probably based on requests by fair bankers in 1620 and 1635, that the usage of the endorsed bills was forbidden since it brought abuse, disorder and confusion into the clearing mechanism. Only in 1666 after vehement protests by merchants who were accustomed to the endorsement technique from the financial centers of Europe like Lyon and Antwerp was the judgement annulled. However, a regulation from Lyon 1678 restricted the use of transferred bills from the Italian towns of Venice and Bozen.(Haristoy 1906, pp. 309f.) This was probably due to the fact that these exchange places did not allow for endorsement (Schneider 1991, pp152f.) Hence, the town officials from Lyon feared disorder in the clearing mechanism. A similar story of resistance to the endorsement technique as documented in Frankfurt can be reported from Italian fair locations. The reason for this opposition could be seen in the strong lobbying of the well-established bankers of these fairs since the use of the endorsed bills reduced the need of the exchange fairs (Prausnitz 1928, p. 21; Neuhaus 1892 p. 11, Schneider 1991, pp.150-3). The reduction of this need due to the endorsement was noted by Raumburger in 1723 (p. 671).

Similar decentralized clearing procedures appeared in the first stock exchange markets. In Amsterdam, traders of stocks and futures started to meet informally during the 1630s, probably once every month to offset their credits and debts in form of stocks and futures (Geldbloom and Jonker 2005, pp. 204f.). Probably from the 1650s onwards the Amsterdam exchange established fixed clearing days every fourth month to settle mutual obligations. An interesting fact is that during the 18th century speculators in English funds created their own clearing days, also four times a year. (Wilson 1941, p. 83ff.). In London, regular clearing days were introduced, probably during the 1740s. However, also in London, traders met informally earlier in coffeehouses to offset their liabilities (Dickson 1967, p. 507ff.).

Another development we find is that national clearing clubs were introduced during the late 18th century and 19th century between banking houses. Early efforts to establish clearing clubs have been documented on the exchange fairs. In Frankfurt in 1642, 23 merchant bankers decided to meet regularly to clear their liabilities. Similar efforts can already be documented by Italian bankers, who started small clearing fairs during the 1570s, when the Spanish bankruptcy led to uncertainty among the merchant bankers (Denzel 1994, pp.316f).

Such agreements can be found by banking houses to clear liabilities in the late 18th century. In London in 1775, several private bankers agreed to build a clearing club, the London Clearinghouse, to settle their liabilities. Before this agreement, bankers had to present checks to each other and to settle individually. Anecdotal evidence suggest that cash messengers from different banks first met informally over breakfast and offset the liabilities so that they only had to cash in the unbalanced positions later on.

The clearing procedure was very similar to the procedure known from the clearing fairs. Each morning during the week the representatives of the banks met and presented the financial obligations. During the day the representatives had time to verify the debts. In case the obligations were approved, the representatives offset their credits and debts. The remaining open positions had to be paid in cash (Seyd 1872, pp.52ff.). The idea of such a clearing club was taken up during the 19th century in Dublin in 1845, in New York in 1853, Paris and Vienna in 1872, and Berlin in 1884 (Koch 1983).

2.4 Efficiency of the Mechanism: Evidence from Merchant Books and Contemporary Witnesses

Having outlined the historical evolution of these clearing mechanisms, it remains to be answered whether or not these mechanisms were efficient in the sense that a high clearing rate could be achieved without paying cash or writing new bills if not necessary. The existence of the mechanism across Europe and the preference by merchants to use the mechanism instead of central public exchange banks indicates that this institutional solution must have worked relatively well. In addition, the large numbers of bills cleared this way gives further evidence (Ehrenberg 1896) that these clearing fairs were successful. It seems that only the economic or political abuse of the institution by manipulating exchange rates or delaying payment or bankruptcy of some major merchant bankers or economic crises led to a downturn of these decentralized clearing mechanisms.²⁵

Another way to approach this question is to analyze one of the few scartefacci which was handed down. The ledger of the 1632 autumn fair in Frankfurt of the

²⁵See Vasquez de Prada 1991, pp. 121-125 for the Castilian fairs; Denzel 1994, 311ff. for Lyon and the Italian fairs.

merchant banker Johan Bodeck gives detailed evidence of the clearing process at work (Brübach 1994, pp.331f.). Bodeck was involved with 77 people during the whole clearing process. This contained reciprocal clearing, cycles and chains. These merchants and bankers were from all over Europe north of the Alps. Clearing partners came from Aachen, Amsterdam, Augsburg, Breslau, Dresden, Frankfurt, Hamburg, Leipzig, Strasbourg, Ulm and from unknown locations. During the clearing, he transacted the total amount of 135000 florins, but only 4000 florins were paid in cash. The rest could be compensated via the clearing procedure. Thus, more than 99.3% could be cleared by mutual settlement. Thus, taking this single booklet as a sample, the clearing technique was very successful. However, can we generalize this single case study or was this high clearing rate pure chance?

Another approach is to analyze the reports of the contemporary witnesses. Whereas an early witness, the merchant Davanzati in 1560 commenting on Besancon looked with some ridicule at the mechanism (Ehrenberg, p.229), writers of the 17th and 18th century, such as Sotus, Molina, Azorius Scaccia and de Turri admired the clearing process. Scaccia and de Turri write that nothing was rarer than money at these clearing fairs (Endemann 1886, pp. 178f.; Neuhaus 1892, p. 10; Haristoy 1906, p. 300).²⁶ Merchant bankers only brought their money for their expenses. Only Koenigk, Raumburger and Marberger (Prausnitz 1928, p. 25) mentioned with the emergence of exchange banks that they were surprised that not more places had a centralized exchange bank since they were better than the decentralized clearing. Based on these reports, the mechanism must have been rather successful.

However if the mechanism was so successful and led to a high clearing rate, why did some of the regulations force merchants to participate and not to pay cash in advance? Why did the statutes mention the freedom of merchants over the order and the clearing partnerships in which they could be involved? If the mechanism worked that well why did merchants have preferences about clearing different clearing chains and cycles? Could the endorsement of the bills of exchange have been so vulnerable for the mechanism in use? We now turn to a theoretical model of the mechanism to answer these questions.

²⁶De Rubys and Clairac argues in a similar way for the Lyon fairs see. See Haristoy 1906, p. 300 Gascon 1971, p. 248.

3 A Model of Medieval Debt Trading

3.1 Setup

We consider a model with a set $\mathbb{N} = \{1, \dots, N\}$ of agents. Each agent $i \in \mathbb{N}$ is endowed with a set of debts $d_{i,1}, d_{i,2}, \dots, d_{i,N} \geq 0$ where $d_{i,j}$ represents the debt that i owes j (and where $d_{i,i} \equiv 0$). We call the complete characterization of a set of debts and credits $\{d_{1,1}, d_{1,2}, \dots, d_{1,N}, d_{2,1}, d_{2,2}, \dots, d_{2,N}, \dots, d_{N,1}, d_{N,2}, \dots, d_{N,N}\} \equiv \mathcal{A}$ an allocation. We will call

$$\sum_{j=1}^N (d_{i,j} + d_{j,i})$$

the trader i 's net position: if i 's net position is 0, we shall call his position balanced. We impose as a constraint on any debt clearing mechanism that the net position of any trader remains unchanged.

We will only consider mechanisms that leave unchanged every trader's net position. Hence, each trader's utility is defined only over the total number of outstanding commitments he has. We define the utility function of trader i as

$$U_i = - \sum_{j=1}^N \alpha_{i,j} d_{j,i}$$

where $\alpha_{i,j}$ is the disutility for agent i of holding a debt from agent j . Note that this can vary between agents; some agent j may be a good credit risk for i and have a low $\alpha_{i,j}$, while some other agent k may be a poor credit risk, and hence $\alpha_{i,k}$ will be quite large. We also assume that the utility of the trader is just a total of the disutility of each credit he is holding from other agents.

In this context, a Pareto efficient allocation is any allocation that maximizes a weighted sum of utilities. Our goal is to show that the mechanisms used at these fairs were able to obtain an efficient outcome.

Our secondary goal is to consider the strategic implications of the mechanisms used. At a fair, an announced debt had to be confirmed by the presumptive debtor. Hence, strategic considerations are important: mechanisms that allow manipulation by denying debts (which the debtor can then pay off later) must not improve outcomes for the manipulator: otherwise, the merchants will have an incentive to deny

debts during the clearing process, which may ruin the ability of these debt clearing mechanisms to function efficiently.

Therefore, we will assume that agents have the ability to deny a debt: that is, for any $d_{i,j} > 0$, agent i can deny the debt, and the mechanism must proceed as if $d_{i,j} = 0$. Formally, the strategy set of the agent i (for a given allocation \mathcal{A}) will consist of confirming or denying $d_{i,j}$ for any $d_{i,j} > 0$. The mechanism will then proceed using the input allocation \mathcal{A}' , which is the allocation including only confirmed debts.

3.2 The Case of Balanced Positions

We first consider the case when each agent i 's financial position is balanced, in the sense that he is neither a net debtor or creditor: that is, for all $i \in \mathbb{N}$, we have that

$$\sum_{j=1}^N (d_{i,j} + d_{j,i}) = 0$$

Note that in this case the only Pareto optimal allocation is unique, and

$$\sum_{j=1}^N \alpha_{i,j} d_{j,i}^* = 0$$

for all $i \in \mathbb{N}$.

In this section we first wish to consider the *cycle removal* mechanism. For this mechanism, we search for a cycle of agents $i_1, i_2, \dots, i_M, i_{M+1} = i_1$ where $i_a \neq i_b$ for $a \neq b$, $a, b \in \{1, \dots, M\}$ and $d_{a,a+1} > 0$ for $a = 1, \dots, M$. Essentially, we are looking for a cycle of agents, each of whom owes the next agent a positive amount. We then “clear” the cycle by setting letting $\hat{d} = \min_{a=1, \dots, M} \{d_{i_a, i_{a+1}}\}$ and subtracting \hat{d} from $d_{i_a, i_{a+1}}$ for all $a = 1, \dots, M$. While the cycle removal clearing mechanism obviously applies to the case when only cycles are cleared, it also incorporates the case where merchants were required to pay cash at the fair so that the ending positions were balanced.

Note that we have not defined in what order the cycle removal mechanism removes cycles. However, the exact order of the cycle removal does not concern us, as it does not affect the final outcome:

Proposition 1 *If all agents have a balanced position, any cycle removal mechanism will completely clear all debts and hence is efficient.*

The essence of the proof lies in accounting: if some agent i has a debt, then the agent j to whom i owes a debt owes a debt in turn to someone else, as his position is balanced. Since all positions are balanced, this string of logic can be continued until a cycle is found; there are only N agents, so at some point this chain must bend back in on itself.

Since, with balanced positions, all debts are cleared, we have that it is a Nash equilibrium for agents to truthfully reveal all their debts, since if they reveal all of their debts, they will completely clear all of their positions, which maximizes their utility.

Proposition 2 *If all agents have a balanced position, it is a Nash equilibrium to reveal all debts.*

The easiest way that an agent could misstate his position is by not entering the cycle-clearing mechanism at all. However, since the proposition states it is a Nash equilibrium to truthfully reveal all of one's debts, it is a Nash equilibrium for all traders to enter the mechanism, a corollary of the above result is that all agents will wish to enter the mechanism.

Corollary 1 *If all agents have a balanced position, it is a Nash equilibrium for all agents to enter the mechanism.*

3.3 Unbalanced positions

However, if agents do not have balanced positions, the nice properties of cycle removal mechanisms break down. First, a particular cycle removal mechanism will not necessarily be even Pareto efficient, much less efficient in the sense of minimizing the total remaining debts. Consider the example in figure 1, where each arrow denotes the owing of 100 florins: A owes E and B , who owes both C and is owed by F , etc, and suppose that $\alpha_{i,j} \equiv \alpha$ for all i, j . Then a cycle removing mechanism may well choose to remove the cycle A, B, C, D, A first, after which no more cycles can be removed. Note that each agent in the removed cycle has one 100 florin open position

Figure 1:

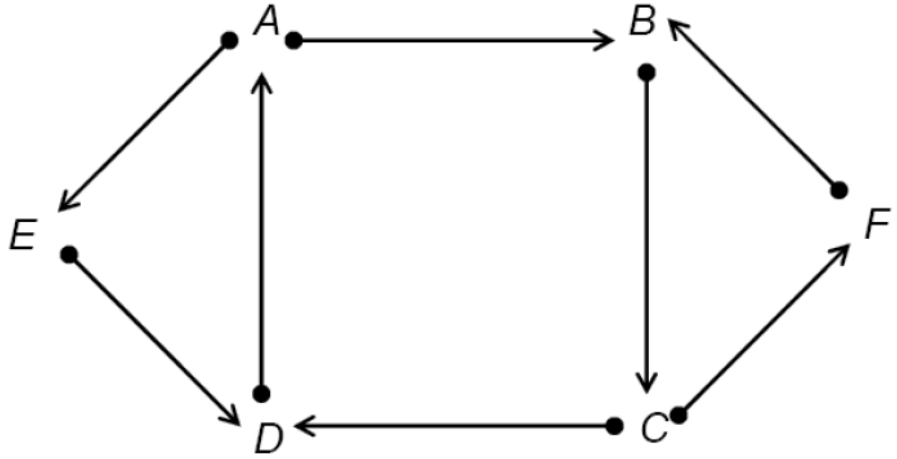


Diagram of possible allocation. An arrow between i and j represents $d_{i,j} = 100$

after the cycle clears, and the two agents not involved, E and F , have 200 florins of open positions. Even though their net position is zero, they can not clear their accounts using just cycles, as their creditor is a net creditor and their debtor is a net debtor.

However, if the cycle A, E, D, A is removed, then the only remaining cycle is B, C, F, B ; after removing these two cycles, only agents A, B, C , and D have open positions of 100 florins. So while the four agents A, B, C , and D may be indifferent, both E and F would be better off if the mechanism removed the smaller cycles first.²⁷ Hence, as the financial positions of fairgoers becomes more complex, we would expect additions to, or a wholly different mechanism from, the cycle removal mechanism that works well when all positions are balanced.

Hence, we now consider chain removal mechanisms. A chain removal mechanism is, in a certain sense, simpler than a cycle removal mechanism: whenever we find a sequence of agents i_1, i_2, i_3 such that $d_{i_1, i_2} > 0$ and $d_{i_2, i_3} > 0$, we call this a chain. For any chain, we let $d = \min \{d_{i_1, i_2}, d_{i_2, i_3}\}$ and subtract d from both. If $i_1 \neq i_3$ we also add d to d_{i_1, i_3} . Hence, since i_1 's debt is passed onto i_3 , the net positions of the

²⁷Note that the fact that we wish to remove the smaller cycles first in this example does not generalize. In particular, note that if we replaced E and F with a chain of several agents, it would be better to remove the larger cycles first.

three agents do not change. For example, if A owes B 100 florins, and B owes C 60 florins, and A owes C 20 florins, then we rearrange the debts so that A owes B $100 - 60 = 40$ florins, and A owes C $20 + 60 = 80$ florins, but B no longer owes C any florins. The result of any chain removal is to set either d_{i_1, i_2} or d_{i_2, i_3} to zero; of course, it may increase d_{i_1, i_3} from zero to d . Note, however, that it reduces the total open debt by at least d , as both d_{i_1, i_2} and d_{i_2, i_3} fall by d (and d_{i_1, i_3} increases by at most d).

We have not defined the order in which we remove chains. One type of chain removal mechanism is that which removes cycles first, and only afterwards removes chains. The transfer of debts could rectify such preferences by merchants. Indeed, the chain removal mechanism can be considered an extension of the cycle removal mechanism. For instance, first using a cycle removal mechanism and then removing the remaining chains (in any order), would still be a chain removal mechanism: we can simply consider removing the cycle as removing the chains in a particular order, as the cycle i_1, i_2, \dots, i_M can be thought of as consisting of the chains i_1, i_2, i_3 , then i_2, i_3, i_4 , etc.

Furthermore, the chain removal mechanism is exactly what is necessary in order to achieve efficiency, even when positions are unbalanced:

Proposition 3 *Any chain removal mechanism will result in each trader having only debts or only credits.*

The idea of the proof is straightforward: if some agent has both a credit and a debt, we can use these to find a chain.

Note, however, that the chain removal mechanism is not deterministic: if positions are unbalanced, then different allocations can result from the same starting point, depending on the order of the removal of the chains. Consider the case when A and A' both owe B 50 florins, who in turn owes C 50 florins. Then, depending on the order of chain removal, either A or A' will owe C 50 florins, while the other will still owe B 50 florins.

Hence, when merchants have preferences over their debtors, it is not necessarily the case that removing a chain results in a Pareto superior allocation; removing a particular chain may make one of the traders worse off, as he now has a debtor whom he disprefers. In particular, then, if positions are unbalanced (and cash payments to settle positions are not required) and merchants have strong preferences over their

debtors, the mechanism may fail to induce much clearing, as merchants will not allow chains to clear which leave them with worse debtors. For instance, C may prefer A as a debtor to A' , while B prefers A' to A . Then if we clear the A', B, C chain, the resulting allocation will be Pareto inferior to the allocation where we clear the A, B, C chain.

In particular, it may be the case that an agent may not wish to allow certain cycles to clear, so as to avoid exchanging a debt with one member of the mechanism for another. In figure 1 above, then, if B does not wish to hold a debt from C or F , it is important that he be able to keep the A, B, C, D, A cycle from clearing, as then he can ensure that the B, C, F cycle clears instead. If he did not have this option, then the mechanism would suffer, as then B would have an incentive to deny his debt to C , so as to ensure that the cycles he prefers are the ones to clear.

Another motivation for wishing to choose the cycles that clear is that the merchant may have preferences due to the exchange rates that were used for the clearing. It may be that clearing a particular chain would force the merchant to exchange debts at what the merchant perceives is an unfavorable exchange rate. Hence, at fairs where debts of several currencies are exchanged, it is even more important to give merchants the freedom to choose which chains clear in order to ensure willingness to participate in the mechanism.

However, when agents do not have preferences over which debts they hold, the chain removal mechanism has even stronger strategic properties than the cycle removal mechanism: in particular, it is an optimal strategy for all players, regardless of the actions by other players, to truthfully reveal their debts.

Proposition 4 *Suppose that $\alpha_{i,j} = \alpha$ for all $i, j \in \mathbb{N}$. Then it is a (weakly) dominant strategy for all agents to truthfully reveal their debts under a chain removal mechanism. Furthermore, the resulting allocation is Pareto optimal.*

The key idea here is that the removal of any given chain can only help the individuals involved. When removing a given chain A, B, C , the utility of A either does not change (if $d_{A,C} \geq 0$) or increases (if $d_{A,C} < 0$). Similarly, the utility of C either does not change or increases. However, the utility of B is increased by $2d$, where $d = \min\{d_{A,B}, d_{B,C}\}$. Hence, all three agents within the chain or at least weakly better off when the chain clears. This proposition applies particularly to the

case where merchants participate in a clearing club, where the assumption that the disutility from a debt is the same across club members is reasonable to apply.

4 Discussion of the Results in Historical Context

We now consider these theoretical results in their economic and historical context. Theory predicts efficient outcomes if participants are willing to get involved in clearing chains and clearing cycles. In this case a merchant who participates in the clearing mechanism can clear all his debts and credits up to his net position as long as everybody else participates. In this way the decentralized search and matching can be rationalized. Furthermore, a merchant can do the clearing in any order. If the composition of the liabilities of the bills allows several clearing paths, then the clearing order does not matter. Therefore all we need for the success of the clearing is that the merchants meet at a specific time and work through the various chains and cycles: no centralized authority is necessary. This is what we found as customary practice earlier on and later regulated in the exchange laws. Crucial in this process is that no questionable bills be used since this would destroy the clearing sequence. Thus, the common practice in the legislation to sort out these bills *ex ante* can be explained. The fear of using endorsed bills can also be interpreted along this line. As long as the legislation and the enforcement of these liabilities were not clear, endorsed bills could bring disorder into the mechanism as judged by the Frankfurt court.

The willingness of a merchant to participate in a clearing cycle or clearing chain *ex ante* depends on the expectations of balanced positions *ex post* or in case of expected unbalanced positions on the likelihood that a creditor gets paid in cash or makes a satisfactory deal by drawing on new bills. If either of these conditions is satisfied, he will participate in any clearing cycle or chain. This way, we can understand the strong fair regulations on balancing positions for example in Besancon or Lyon, i.e. paying cash before the end of the fair and otherwise being declared bankrupt and excluded from any future clearing processes, since this increases the willingness of the wealthy merchants to participate in the clearing mechanism. However, if a merchant expects unbalanced positions at the end, for example if he learns that many merchant bankers will not be able to balance their debts, he will stick to clearing cycles since this guarantees him direct clearing; even a bankrupt clearing partner *ex post* will not harm him according to the regulations discussed earlier on. If he selects chains

he must be careful not to pick a new partner who, as is written in the merchant booklet, turns out to be a bad debtor. If he prefers using cycles only, he might have preferences over the order of the clearing process, since this can determine the outcome and his personal clearing rate by only using cycles. Consequently, we can rationalize all the regulations we found in the exchange legislations which gave the merchant the freedom to participate in any cycle or chain, and to choose in which ordering he liked to clear, as otherwise merchants may have incentives to misreport their positions in order to change his eventual set of debtors. Following this line of argument, we can also understand why merchants sometimes preferred clearing debts in cash, since they preferred receiving cash *ex ante* from the original debtor to trying to cash in the debts from a new debtor due to the clearing process. At the same time the officials who organized the clearing fair had an interest in keeping in as many debtor-creditor pairs as possible because this created positive externalities for other merchants who participated in the clearing. Hence the discussed regulations from Bozen or Leipzig on forced participation can be rationalized in this way.

In addition, the use of strict regulations that forced participants after the mutual settlement to balance their positions can be explained. In an early stage, when such a mechanism was set up by a small number of merchants, we can expect reputational forces to have kept the mechanism running. However, when the number of participants increased, it was necessary to impose legal sanctions. An alternative to this are clearing clubs, where the number of participants is restricted to merchants who know each other. However, the clearing mechanism allows some anonymity. As long as merchants only participate in cycles it does not matter if they need to rely on reputation or legal enforcement *ex post* since the common amount can be cleared anyway. In addition, in clearing cycles and clearing chains each participant knows at least one partner with whom he had already done business. Finally, in case one participant rejected a certain clearing chain, he still could search for other clearing partners to proceed with the clearing. Achieving a Pareto efficient clearing depends then on the number of theoretical clearing paths available and on the original liability composition and structure of the merchants.

Thus, the mechanism is rather robust and we can expect high clearing rates. The question then remains under which circumstances the mechanism becomes vulnerable. The mechanism is robust against small shocks and the bigger the clearing location, the less likely it is that small disturbances will influence the clearing process. However,

the mechanism is not robust against heavy shocks as we can observe for example during the second half of the 16th century in Lyon. If too many merchants cannot pay their debts, then participants can not only expect unbalanced positions, but also a shortage of money on the aftermarket, since too few bankers come out of the clearing with positive net positions. Furthermore, we can expect less willingness to give future credit to probably bad creditors.

Observing the empirical success and the theoretical efficiency of the decentralized clearing mechanism explains the limited success of the public clearing banks. A clearing bank can always replicate the Pareto efficient clearing because it works as an intermediary who takes in and hands out the compensation directly. However if we expect Pareto or close to Pareto efficient clearing of the decentralized clearing houses, what extra benefits can the central bank offer to the merchants? The public bank can work as an intermediary who enforces unbalanced positions. In contrast to the decentralized clearing house, a creditor can always rely on the same partner and does not have to deal each time with new debtors, who are determined by the sequence of the decentralized clearing process. The bank orders of Nuremberg indeed imply such a rational by their customers. The merchants of Nuremberg were willing to hand in bills which they could not clear easily; for these bills, they preferred to rely on the enforcement of the bank. However, the document also informs us that they handed in only these bills; decentralized clearing for the other bills was still preferred. The enforced participation constraints by other banks also point in this direction. A follow-up question can then be asked: why did merchants prefer not to go to these public banks? We see from sources that document the early phases of these institutions that some exchange banks were chronically short of money. Furthermore, town officials, who governed these banks were always passing new regulations for these banks (Fuchs 1954, pp.55-8). Therefore, the lack of trust to deposit all the bills into these banks comes as no surprise. During the early 18th century Marberger (1717, pp. 98f.) comments on this problems (Schneider 1991, p. 142). In addition, the revelation of private business information to a new public institution was probably not supportive of these banks.(Velde 2009) Finally, at fairs exchange rates were negotiated by representatives of different merchant groups. In the public banks merchants had to rely on the decision makers of the bank. Thus, based on this bargaining argument the participants of the fairs could expect better exchange rates at exchange fairs than in public banks.

5 Conclusion

This paper examined the evolution of a decentralized multilateral debt clearing algorithm for non- or limited-tradable debts during the late medieval and early modern period in Europe. We constructed a simple theoretical model of the mechanism and showed that the mechanism could lead to very high clearing rates. In this way the common use of the mechanism can be rationalized.

We first examined the history of the mechanism. We analyzed the early emergence of this mechanism on Late Medieval markets and fairs and showed how the clearing algorithm developed into a standardized procedure embedded in a legal framework during the early modern period in use all over Europe. We identified the main elements of the procedure, based on legal sources and writings of contemporary witnesses. We then set up a model which simulates the mechanism and identifies the equilibrium outcomes and related strategic behavior of participants.

We showed that the functioning of the mechanisms depends on the balance of positions of merchants *ex ante* and the use of clearing cycles or clearing chains. If positions are balanced, then efficient clearing is always achievable with clearing cycles and also with clearing chains. If positions are unbalanced, it is necessary to use not only cycles but also clearing chains as to achieve Pareto efficiency. If chains are used, efficiency can be achieved at the price of transferring debts from one merchant to another. Furthermore, whereas in the case of balanced positions the algorithm is deterministic, in case of unbalanced positions it is not. If cycles are used, depending on in which order the cycles are removed, different levels of clearing efficiencies can be achieved. If chains are used, merchants can always reduce their position to being solely a creditor or debtor, but depending on the clearing order the distribution of debt transfers among merchants differs *ex post*. These properties can lead to strategic behavior of merchants in the form of strategic misrepresentation of information and non-willingness to participate in specific cycles or chains. This in turn reduces the efficiency of the clearing.

These results can explain the self-organizing emergence of this mechanism during the late Middle Ages in fair and financial markets and why during the early modern period a specific form of the mechanism embedded in a legal framework evolved all over Europe. In addition, it can be shown why the mechanism was in general robust and only vulnerable in cases of strong economic shocks or of political abuse. This

made is it difficult for competing institutions such as the public exchange banks to take over the clearing business.

These results open up new questions for future research. The results here analyze the microeconomic properties of these clearing mechanisms. However interesting questions related to trade and credit flows on a macroeconomic level could be discussed. It is well known that all these clearing locations were linked and embedded in a common network. Therefore the evolution and robustness of this network related to the microeconomic findings of this paper should be further discussed. In particular, the role of unbalanced trade and credit flows would be of great interest.

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7 Appendix

Proposition 1

Suppose not. Then after all cycles have been removed, there exists some agent i_1 who has both debts and credits. Hence, for at least one individual i_2 , we have that

$$d_{i_1, i_2} > 0$$

Since this is true for every agent i , for any agent i_a with $d_{i_{a-1}, i_a} > 0$, there exists an agent i_{a+1} such that $d_{i_a, i_{a+1}} > 0$, as i_a holds a balanced position. Hence, we can construct an ordered list of agents $i_1, i_2, \dots, i_N, i_{N+1}$ for whom $d_{i_a, i_{a+1}} > 0$. Since there are $N + 1$ agents in this list, there must be an a and b such that $1 \leq a < b \leq i_{N+1}$ such that $i_a = i_b$. Hence, there still exists a cycle $i_a, i_{a+1}, \dots, i_{b-1}, i_a = i_b$, which contradicts the assumption that all cycles have been removed.

Proposition 2

If all other agents truthfully reveal, it follows from Proposition 1 that agent i will clear all his debts by truthfully revealing. Since this is the best agent i can hope to do under any allocation, this is a best response.

Proposition 3

Assume that all chains are removed and the outcome is not efficient. Then there exists an agent i whose has both a debt with some agent j and is owed a debt by some agent h . Hence, h, i, j constitutes a chain and not all chains have been removed, a contradiction.

Proposition 4

Let \mathcal{A}' be the allocation given a truthful revelation by agent i and some revelation by other agents. Then a chain removal mechanism is strategy-proof if i does not want to deny his debt with any j such that $d'_{i,j} > 0$. Letting $\hat{d}'_{i,j}$ denote the announcement by i , we have that i 's ending utility will be

$$- \left| \sum_{j=1}^N \hat{d}'_{i,j} \right| - \sum_{j=1}^N d'_{i,j}$$

which is clearly less than or equal to

$$- \left| \sum_{j=1}^N d'_{i,j} \right|$$

as $d_{i,j} > 0$ (as the agent can only deny debts). For the last statement, note from the previous theorem that all agents when all agents report truthfully, all agents are reduced to their net positions. Since the disutility from any debtor is the same as from any other debtor, this implies that the allocation is Pareto efficient.