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Medieval Matching Markets

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Abstract

We study the implementation of brokerage regulations as allocation mechanisms in wholesale markets in pre-modern Central Western Europe. We assemble a data set of 1609 sets of brokerage rules from 70 cities. We analyze the incentives created by the rules that were implemented, compare cities that implemented brokerage to cities that did not, and analyze the choice of how brokers should be compensated and the effect this has on market outcomes. Empirically, we find that larger cities, cities with trade-geographic advantages, cities with merchant interests, and cities with universities were more likely to implement brokerage. We also find that brokers were more likely to be compensated with price-based fees in markets with greater heterogeneity in products and preferences, and with unit fees in markets for more homogeneous products – exactly as our theoretical analysis suggests is optimal.

Keywords: preindustrial markets, market microstructure, efficient matching
JEL codes: D4, N23

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1 Introduction

How markets are organized, and what institutions and mechanisms exist to facilitate trade and determine the allocation of goods, is an important question in economics. Nobel Prize winner Al Roth notes, “Traditional economics views markets as simply the confluence of supply and demand. A new field of economics, known as ‘market design,’ recognizes that well-functioning markets depend on detailed rules” (Roth 2007). But while the tools that modern market designers have at their disposal – game theory, lab experimentation, computational simulation – may be relatively new, people have been regulating markets and trying to improve their performance for many hundreds of years. As Roth writes in his new book, “The design of markets, via marketplaces, is an ancient human activity, older than agriculture” (Roth 2016). Challenges to market design today – informational asymmetries, strategic behavior, market thinness or congestion problems – are often problems that were present in earlier times as well.

Studying historical markets is particularly interesting during historical episodes when strong information asymmetries existed and market institutions were poorly developed. This typically happened in environments where sudden economic changes occurred and new allocation problems arose due to new forms of economic interaction. Late medieval Europe can be characterized as such a period. A revival of inter-regional trade occurred, and merchants traveled from their home towns to other cities to sell and buy goods (Lopez 1976). This period has been identified as the origin of pre-modern growth in Western Europe. An increase in trade led to specialization and market integration. Complementary to this process, institutions developed which supported economic interaction. Recent studies have analyzed such institutions and concluded that one key driver of pre-modern growth was the successful implementation of enforcement mechanisms (both formal and informal) to overcome the commitment problem in long-distance trade (Milgrom et al. 1990, Greif 1993, 1994, and 2006b, Greif et al. 1994). Aside from such enforcement problems, however, informational asymmetries between buyers and sellers also created allocation problems in pre-modern towns. Town leaders were concerned that foreign merchants supplied sufficient input products for local production and consumption goods, and that citizens got equal access to these products (Hibbert 1967). Town policies typically promoted the idea of two-sided markets where buyers and sellers could trade directly, without interference by private intermediaries who could buy up and re-sell products based on speculation and monopoly power. Thus, towns were concerned with creating attractive market platforms which served both foreign merchants and local customers at the same time.

In this paper, we examine how trade (in particular wholesale trade) was organized, and how this type of allocation problem was solved. We focus on one particular mechanism used in many pre-modern towns: intermediation in the form of brokerage. Merchant towns implemented brokerage in wholesale markets as a sort of centralized matchmaking mechanism: a few licensed brokers specializing in a particular product were given the exclusive right to offer a service pairing foreign merchants with local buyers, and their behavior was strictly regulated. Brokers were not allowed to do any business on their own behalf, and were restricted in what information they could disclose. They received a pre-defined fee based on the transactions they generated. We show how brokerage implemented in this way would have increased the allocative efficiency achieved through trade and ensured a reasonable surplus for both sides of the market, and conjecture that this is why it was done.

Brokerage regulations were very similar in different cities and at different times, but some of the details, such as the calculation of broker compensation, varied in systematic and predictable ways. We show that differences in compensation mechanisms were related to the characteristics of the product being traded, and that this adaptation of the brokerage mechanism to the environment created incentives for brokers to create more efficient matches. At the same time, the mechanism ensured that aside from the small brokerage fee, the entire surplus from trade was divided between the buyer and seller. We also show that brokerage regulations tended to be implemented in larger cities with stronger commercial potential and interests. These results support the argument that formal market policy, in the form of brokerage regulations, was indeed used to support economic transactions which might have further fostered economic growth.

We study 227 cities in Central and Western Europe, roughly in the area of the Holy Roman Empire north of the Alps, during the period from 1200 to 1700. This area and period is particularly appealing for empirical investigation because local municipalities were typically economically and politically autonomous. Thus, each city could implement its own types of regulations and allocation mechanisms, leading to potentially rich variation in detail. We identify cities with (and without) brokerage regulations, finding 70 cities with brokerage and 1609 sets of regulations. We find certain dominant brokerage designs with specific combinations of rules. We analyze these combinations of rules, using a simple theoretical model to predict the relationship between the rules and the market outcomes that would follow, and characterize welfare and surplus division properties. In particular, we predict a relationship between the basis of broker compensation and the characteristics of the product being traded. We then test these predictions empirically, examining the historical determinants of the exact regulations in use, and find support for our theoretical predictions. We also compare cities with brokerage to cities without, and find that larger cities were more likely to have brokerage, as were cities with trade-geographic advantages, cities with merchant interests, and cities with universities.

One contribution of our paper is to the large body of literature studying the role of institutions to explain economic growth. Scholars of pre-modern growth have focused on institutions (formal and informal) which secure the exchange of goods and property rights and in this way enable growth and development (North 1981, Acemoglu et al. 2005, Greif 2006). The functioning of such institutions is a precondition for a successful implementation of more complex and differentiated allocation mechanisms. The study of allocation mechanisms themselves, however, has been very much neglected in the literature so far. Our paper contributes by studying a complementary class of institutions which could have contributed to economic growth. A related paper by Cantoni and Yuchtman (2014) claims that the implementation of market regulations (in the form of market privileges in general) was facilitated by universities, which educated administrative town personnel who was able to read and write down such regulations. Our empirical study indeed supports such a relationship.

Secondly, our paper relates to the analysis of market design in a long run perspective. The recent literature on market design focuses on modern market design problems (Milgrom 2004, Roth 2008). By extending this line of research to a long-run historical analysis, we are able to shed light on the identification and persistent use of specific market clearing techniques, and begin to shed some light on a neglected institutional dimension: the long-run evolution of the active design of market mechanisms. Such a line of research is only now in the process of arising.[1] Furthermore, we contribute to an established literature on intermediation. This literature argues that interme-

[1]For instance see Boerner and Hatfield (2016), Bochove, Boerner and Quint (2012), or Donna and Espín-Sánchez (2015).

diaries improve the welfare of consumers and suppliers by reducing or eliminating the uncertainty associated with searching for a satisfactory match. Transactions with recognized centralized intermediaries can supplant decentralized search and bargaining, so that customers and suppliers avoid the costs of decentralized search. In addition, trading through a broker may offer "high-value" traders a greater chance of trading or more favorable expected prices (Gehrig 1993, Yavas 1992 and 1994, Spulber 1996, Neeman and Vulkan 2010, Rust and Hall 2003). This literature typically studies the decentralized evolution of different forms of intermediation. Our paper complements these studies by analyzing a "top-down" implementation of brokers as centralized matchmakers.

Finally, our study contributes to a better understanding of medieval and early modern markets in general, and of brokerage in particular. Studies in economic history have mainly focused on market access and monopolistic structures in merchant cities. Particular attention has been given to guilds in these studies. A main finding by a majority of scholars is that monopoly power of guilds was rather limited; although some guilds had limited monopolies on good production in their home towns, the selling on local markets was mostly competitive, and exchange of products between towns was open and led to competition (Swanson 1988, Munro 1990, Hickson and Thompson 1991, Epstein 1998 and 2008, Richardson 2004). A counterpart to this literature argues that guilds acted as rent seeking institutions, which hindered free exchange and competition (Ogilvie 2004 and 2014). Yet another perspective is presented by Gelderblom and Grafe (2010), who find (among other things) that guilds supported the matching of buyers and sellers where no market institutions existed. Economic and legal historians who have studied pre-modern brokerage have mainly focused on single case studies, aiming for a fuller historical characterization of brokerage in individual instances. From an economic point of view, they identified brokerage as a multi-functional institution which performed commercial intermediation, certification of the quality of goods, tax collection for the town, and the notarization of deals.[2] Gelderblom (2013) emphasizes the role of innkeepers as official intermediaries and discusses their replacement by specialized (official) brokers over time in the late medieval/early modern Netherlands. Our study complements these studies with a quantitative analysis of the evolution of brokerage, a formal analysis of incentives created by brokerage, and an evaluation of brokerage from a market design and policy perspective. Such a methodological

[2]For a survey of some of the findings of the early literature, see van Houtten (1936). For a synthesis of these findings for some Dutch towns, see Gelderblom (2013), and for a more extensive literature discussion and empirical investigation of this multi-functionality see Boerner (2016).

approach is closely related to Greif (1993, 1994, 2006), who studies pre-modern institutions from an incentive-theoretical point of view and derives growth and welfare implications.

Our paper is structured as follows. Section 2 discusses the historical economic environment, and describes the evolution and some common characteristics of the identified brokerage regulations based on a case study of Frankfurt. Section 3 presents the data set and identifies specific brokerage rules implemented. Section 4 builds a theoretical model and gives some theoretical results about the value of brokerage and conditions favoring one or another type of broker compensation. Section 5 gives the empirical analysis; Section 6 concludes. Theoretical proofs and extensions, tables of empirical results, and maps are in the Appendix.

2 City Growth, Trade, and Brokerage

2.1 Environment

At the beginning of the 11th century, Europe entered a period of economic expansion and population growth. This began in the Mediterranean area and later spread north of the Alps during the 12th and 13th centuries. The population growth was strongly linked to the foundation of towns and increasing urbanization (Bairoch 1988). This increase in urbanization and city growth was caused by the so-called Commercial Revolution, an intensification of trade among different regions of Europe (Lopez 1976). This included not only trade within the Mediterranean and Baltic/North Sea areas, but also continental land trade between northern and southern Europe. In addition, with the discovery of the New World, transatlantic trade began to become relevant during the 16th and in particular the 17th century. Western areas, and especially towns with access to transatlantic trade, grew even more rapidly (Bairoch 1988, Bairoch et al. 1988, Acemoglou et al. 2005).

The expansion of interregional long distance trade was characterized by merchants traveling to foreign cities to trade goods. A large variety of products were traded in this way: textiles and clothing products, dyes and spices, basic foodstuffs like grain, fish or wine, and finally construction materials and metals (Postan 1987, pp. 168-178, Kellenbenz and Walter 1986, p. 867ff., Kellenbenz 1986, pp. 262-71).

A number of different institutions evolved gradually during the Late Middle Ages and early modern period to facilitate this sort of trade (Verlinden 1965, Postan 1987, Dijkman 2011, Gelderblom

2013). In the area and period we study, the most important were brokerage and spot markets, the latter taking the form of market places and warehouses. Both brokerage and spot markets were found both in permanent markets and temporary fairs, and both were organized and tightly regulated by the town officials.[3] Other institutions and practices appeared as well. Local agents such as innkeepers would sell goods on behalf of foreign merchants for a commission. More permanent partnerships, with partners located in geographically separated business offices (referred to as factories), only developed over time, and in the period we study represented a small fraction of trade (de Roover 1971, pp. 70 ff.; Hunt and Murray 1999, Boerner and Ritschl 2009).[4] Public information about the price of goods being traded was typically not available during the period we consider. Although informal lists circulated earlier, the first public market price lists were not available before the end of the 16th and early 17th centuries for some selected goods, which were produced by the brokers based on their experiences during the previous trading week (McCusker and Gravensteijn 1991). Finally, the use of more sophisticated centralized market-clearing techniques such as auctions mainly appeared in wholesale markets from the 17th century onward (van Bochove, Boerner, and Quint 2012).

This is the institutional business context within which organized brokerage evolved. Before we go into a more systematic analysis, we discuss some basic facts about brokerage as found in the city of Frankfurt.

2.2 Brokerage: The case of Frankfurt

Frankfurt is an interesting case to study, since it was one of the most important economic and political cities during the period and area of our investigation. It grew from a few thousand inhabitants from the 13th century to more than 28,000 by 1700 (Bairoch et al. 1988). Such a city size was moderately large during the period of our investigation, but cannot be compared to other economic centers such as Cologne or Antwerp during the 14th or 15th century or Hamburg

[3]Market regulations were issued by the city council or directly by a local worldly or ecclesiastical duke. A city council typically represented some subset of the citizens, such as patricians, guild members, representatives of local dukes, etc., but did not represent the town's citizens in an equal way. For example see Isenmann 1988.

[4]In particular some Italian family firms during the 14th and 15th century and South German firms during the 15th and 16th can be found in some of the bigger towns of the area of investigation. Examples include some factories of Italian firms during the 14th and 15th century in Brugges, or branches of south German firms as the Fugger Company during the 15th and 16th centuries in Antwerp (de Roover 1965, Kellenbenz 1990, Schneider 1989). These companies provided information flow based on internal postal services, as public messenger services served information flow between town officials and did not carry business information (Gerteis 1989).

and Amsterdam during the 16th and 17th century. However, with the Emperor Friedrich II's confirmation of the right to hold fairs in 1240, and the extension of this privelege by the Emperor Ludwig der Bayer in 1330, Frankfurt became a market place and financial center with interregional importance (Dietz I 1910, Rothmann 1998, Holtfrerich 1999). In addition, with the decree of the Golden Bull in 1354, Frankfurt became the city where dukes and bishops of the Holy Roman Empire would gather to elect a successor when the king died. Frankfurt was a Free Imperial city, meaning the town was politically and economically independent. Economic policy was made by the municipal government and the town was directly protected by the German Emperor.

Brokerage regulations can be regularly documented from the middle of the 14th century and last until the end of the 17th century (which marks the endpoint of this investigation) and beyond (Schubert 1962). The specific regulations and underlying intermediation mechanisms we can document are very detailed and differentiated. The smooth functioning of the allocation process must have been a concern of the town officials of Frankfurt, and they likely established a strong expertise due to their commercial interests. This can be inferred, for instance, from the organization of brokerage and communication of the regulations to different foreign merchant groups during fair times (Rothmann 1998, pp. 122ff). It is also reflected in communication from 1613, when the increasingly-important city of Leipzig asked Frankfurt for advice on how to design their brokerage regulations and mechanisms. Frankfurt sent their regulations, also referring to other towns like Cologne, Hamburg, and Nuremberg (Moltke 1939, p. 15f.). The brokerage regulations of these towns might have worked as role models for other cities; in any case, they are fairly representative when we look at the whole sample in the next section.

Brokerage was implemented as a sort of centralized clearinghouse mechanism: a fixed number of licensed brokers had the exclusive right to match buyers and sellers. A broker was sworn in by the town and licensed for a specific product genre: from the middle of the 14th century we find brokers for wine, meat, horses, and herring (Dietz I, 1910, pp. 379f., Schubert 1962, pp. 28ff.). By the end of the 14th and beginning of the 15th century, brokers for other product genres can be observed: among others for cloth and textile industry input goods such as wool, silk, skins and fur, then spices, metals and iron ware, cattle, property, rents, and bills of exchange.

The regulations restricted the intermediation activities of the brokers to matching buyers and sellers and prohibited brokers from any private business, such as buying and selling for themselves or partnering with others who did.[5] For a successful match they received predetermined fees either per unit[6] or based on the final price.[7] The fee structure was specified separately for each product, and was quite low compared to the selling price.[8] This fee could not be changed and was typically split equally between the buyer and the seller.[9] Regulations for some product genres ask brokers to work in groups and share their fees (Schubert 1962, pp. 45f.).[10] The use of a broker was typically not mandatory: only in very few cases over the whole period we study do we find evidence that a broker had to be used.[11] Most of the common rules, as well as the common combinations of rules, appeared throughout the sample.

Brokers were normally citizens, typically local merchants or producers. During fair times, some foreign merchant groups were allowed to bring their own (product specific) brokers, who had to follow the same regulations as the permanent local brokers (Schubert 1962, pp. 37f.).

The brokerage regulations from Frankfurt also reveal a long catalog of penalties for not following the rules – in particular, for violating the private business constraint, asking higher fees, or performing brokerage without being an officially sworn in broker. In earlier regulations during the 14th century, the punishment was banishment from the city for one year and losing one's job.[12] Later regulations from the 15th century on mainly imposed fines.[13] We have no detailed source material on the application of these punishments, but detailed evidence of the application of similar punishment mechanisms for brokers can be extensively documented in the city of Cologne during the same period of time (see Boerner 2016).

The regulations also inform us about the political motivation of the town and their representative officials in implementing these orders (Schubert 1962, pp. 69ff.). We find mainly two types of

[5]See for instance the broker oath from 1465 (Buecher 1915, 213f.)

[6]For example: three *Schillinge* for one *Fuder* of wine in 1373 (Buecher 1915, p.325); three *Heller* for one cow or swine in 1373 (ibidem, p.221); two *Groschen* for one ton of herring in 1415 (ibidem, p.241).

[7]For example: four *Heller* at an outdoor market (six *Heller* during a fair) from each pound in the price of a horse in 1360 (Buecher 1915, p. 237); one *Groschen* for each 100 guilders for bills of exchange around 1450 (ibidem, p.250).

[8]For a general discussion of brokerage fees relative to good prices see Gelderblom 2013.

[9]However, some regulations (particularly early ones) indicated that for some products the seller had to pay the fee: for instance, for the previously mentioned brokerage fee for horses, only the seller had to pay the fee, and for the previously mentioned fee for pigs the buyer had to pay less.

[10]For example, in the wine brokerage fees mentioned above from 1373, wine brokers had to share profits.

[11]This seems to only regularly have been the case for small retailers (called "Hoecker" ("sitters")) who bought foodstuff products such as eggs, milk, cheese, etc. for daily re-selling on the streets of Frankfurt during the second half of the 14th century – for an example from 1377, see Buecher 1915, p.227. For single observations for a few other products see Schubert 1962, p.57.

[12]For example in 1357 (Wolf 1969, pp. 11ff.) or 1360 (Buecher 1915, pp.211f.).

[13]For example in 1406 (Buecher 1915, pp.214f.) and 1466 (Wolf 1969, p.356).

motivation. During the 14th century, regulations state that these brokerage regulations have been implemented in the interest of the town and their citizens. (For an example from 1350, see Buecher 1915, p. 325.) Secondly, the regulations state that the broker should treat all his customers in an equal way, independently if they are rich or poor, local or foreign. Such statements can be found throughout the period of investigation; the equal treatment between locals and foreigners, however, we only observe from the 15th century onward.[14] In some regulations, related statements of equal treatment are explained in more detail when they talk about information sharing between the broker and one side of the market. The broker was not allowed to inform the buyer if the seller was in a hurry to sell his goods, nor to tell the seller if the potential buyer was rich or poor.[15] He also could not reveal wrong estimates of the value of a product (too high or too low) to one side of the market.

From these sources we can clearly infer concerns about information asymmetries between both sides of the market which went beyond knowledge of who was selling or buying which types of products, and concerned product valuations and price preferences of market participants and related concerns about strategic behavior. (If a seller learned from a broker that a buyer could afford to pay a high price, he would have a stronger incentive to demand a high price; if a buyer learned about past prices, or that the seller needed to sell his goods quickly, he could understate his own willingness to pay.[16]) Thus, the broker was a powerful intermediary, who had the information and knowledge to influence trade and price formation or even to use the information to do private business. Regulations and punishment for such behavior indeed show the fear of this abuse, and the importance of this intermediary function in improving the allocation process.[17] Consequently, the role of brokerage was to support the searching and matching of buyers to sellers, and to solve

[14]For examples: from 1360 (Buecher 1915, p.211), ca. 1450 (ibidem, p. 249), 1460 (ibidem, p.224).

[15]Such statements can be found for instance in brokerage rules from Frankfurt 1406 and 1465 (Buecher 1915, pp. 211ff. and 213ff.) and 1685 (Beyerbach(1818,pp.700ff.).

[16]The brokerage regulations from the Alsatian merchant town of Schlettstadt from the early 16th century gave exactly this second reason for ordering the broker not to reveal information to one side of the market (Geny 1902, p. 988-9).

[17]The conscious implementation, self-reflection and outside perception of market policy in form of brokerage can also be derived from various source material from other important merchant towns such as Cologne or Brugge. For instance in one source from Cologne, an expert probably ordered by the city of Cologne evaluates different market making activities and regulations, including brokerage regulations. The report concludes that the brokerage regulations in use are good and should be kept (Stein II, 1893-5, pp. 565f.) In a letter from the Hanseatic League to Brugge in 1438 merchants who had earlier left Brugge were negotiating over returning to Brugge to do business. Among other demands, they wrote that they only would come back if the city could guarantee that brokers did no private business for themselves (Hoehlbaum et al. 1876-1939, Hansisches Urkundenbuch, VII n. 389 § 5).

the information asymmetry problems between both sides of the market in a "fair way."

The broker typically served as an intermediary between foreigners and locals; intermediation between foreigners and foreigners developed only gradually, in particular during fairs (Rothmann 1998). Outside of the fair periods, matching between foreigners in the developing wholesale markets in Frankfurt (such as the wine market) was generally prohibited.[18] Specifically (outside of fair periods), brokers mainly matched foreign sellers with local retailers and craftsmen. Looking at the product genres brokers were assigned to in Frankfurt, this was in particular the case for import goods such as foodstuff for local and regional consumption, and input goods for the local cloth (wool, flax, yarn), leather, and fur manufacturing industry (Dietz 1910, I, chapter 4). Foreign sellers typically offered their products in temporary markets, or stored their products in warehouses while in town and sold from there, or sold their products directly from the ships arriving on the river Main. In all these cases, brokers were present to assist in the matching process.

Local producers had less need for brokerage, as they typically sold from better permanent facilities such as specialized product warehouses with fixed assigned stalls. (Examples were the warehouse for local cloth, the *Lederhaus* (leather house) for the tanners, or the *Kürschnerlauben* (furriers bowers) for the furriers (Dietz, I, pp, 179, 187), which could already be documented during the beginning of the 14th century.) The use of a broker between foreign buyers and local sellers might have been useful in cases where no permanent central market place existed and products were traded in a decentralized way, such as wine; in this case, brokers had to guide the customers through different wine cellars.[19]

3 Brokerage regulations

Having discussed brokerage in Frankfurt, we proceed with a more comprehensive study. Our study covers towns in the area of Central Western Europe, basically the outline of the Holy Roman Empire at its largest, as well as eastern neighboring cities in the kingdoms of Poland and Hungary.

[18]See the wine brokerage regulations from 1350 and 1381 (Buecher 1915, pp. 323 ff.). Such restrictions can also be observed in other early brokerage regulations from other towns, in particular during the 14th and early 15th century; see Boerner 2016 for an enumeration of the different towns.

[19]During fair times, when market activities between foreigners were allowed, merchant groups from the same towns or regions typically selling the same type of products would often stay in the same guest houses, which complemented brokerage in facilitating the searching, matching and market clearing further (Brübach (1994), Rothmann (1998)). For a more detailed discussion of the interaction between brokers and other market facilities in Cologne, see Boerner 2016.

Following Bairoch et al. (1988), our investigation covers the years 1200 to 1700, and includes all cities in this area which had at least 5000 inhabitants at some point during this period. This means 227 towns were considered, in 70 of which brokerage could be identified. Map 1 shows all towns considered, and distinguishes those in which brokerage regulations were found from the others. The data are compiled from edited and non-edited sources based on several thousand pages of source material, which have been translated and analyzed by us from different mainly medieval Germanic dialects. We analyzed all edited sources available for the area and period of investigation, as well as complementary archival material mentioned in the edited documents or secondary literature. Additionally, we checked for documented archival material in all cities in the area of investigation mentioned in Bairoch et al. (1988). The quality of the source material is occasionally very fragmented. Source documents are in some cases very short (only a few lines long), in other cases they are several pages long and cover very detailed and differentiated regulations. The composition of our sample of brokerage regulations thus reflects the survival and accessibility of the sources, not a conscious selection on other bases.[20] The first brokerage rules can be dated back to 1241 and more observations can be found during the 13th century, making the 13th century a natural starting point for the sample. Many observations can be found at the end of the sample during the second half of the 17th century and on into the 18th century; due to the time intensive source analysis (which took several years), we stopped our investigation at 1700.

As noted earlier, brokerage regulations were for particular products or product genres.[21] The products covered were basic foodstuff such as fish, grain, wine and beer, cattle and meat, and oil and fat; finished cloths or input goods for the textile "industry" such as raw textile (wool, linen, fustian, etc.) or fur, skin, and leather; spices and similar products (in particular coloring products), construction material, metals, financial products (including gold and silver), and property (land and houses). (See Table 4 for descriptive statistics for each product genre.) All of these categories could be found before 1300 in the regulations from Brugge (in 1252) and/or Augsburg (in 1276). These same broad categories were still found in the 17th century, for example in the documents from Amsterdam or Hamburg; what changes are the specific products found within each. For example, in the category of financial products, the number of regulations about bills of exchange

[20]For a more detailed discussion of the source material see Boerner 2016.

[21]Brokerage regulations normally indicate for which products the regulations applied; only very occasionally, they would include rules "for everything else" to cover less-important products.

increased over time, and stocks appear much later (for the first time in Amsterdam in 1623, and in Hamburg in 1643).

Brokerage regulations for particular goods are typically found along important trade routes for those goods. For example we find wine brokerage along the Rhine/Main area, which was the most important wine producing area of the investigated region (Volk 1993, Rose 2011; see map 2). Similarly, grain was intensively produced in Poland and the Baltics and from there shipped through the Baltic and North Sea (van Tiehlhof 2002, Jahnke 2015); we frequently find grain brokerage along the North and Baltic Sea (see map 3). On the other hand, brokerage for financial products can generally be found in larger (merchant) cities, which were geographically more evenly distributed (see map 4).

3.1 Specific regulations implemented

Aggregate statistics of individual regulations, and combinations of regulations, can be found in table 1. Column (1) and (2) show how frequently different types of rules appear in total and in how many towns.

The brokerage privilege being an exclusive right to match buyers and sellers can be found in 820 observations, from 48 towns. We code brokers as having this exclusive right to act as intermediaries as *brokerage privilege.* Other forms of intermediation were generally not allowed.[22] With a few exceptions, merchants were not forced to use brokers; they could choose whether to use a broker or search on their own for trading partners.[23] We code the cases where merchants were required to use a broker as *forced brokerage.*

Brokers were frequently banned from buying or selling on their own behalf or participating in the business in any other way as described in the case of Frankfurt; they could only facilitate trades between other buyers and sellers. We find such a prohibition in 480 observations in 34 towns. Their fees came out of the price paid in the transaction, and only after the proposed sale was agreed to

[22]Some early sources documented brokers sharing this privilege with innkeepers – in particular, this was seen in the area of the Netherlands and Belgium (see also Boerner 2016), for example in Brugge (Gilliodts van Severen 1881, Gelderblom 2013). Furthermore, there is evidence that during the 17th century in fast-growing cities such as Amsterdam (Noordkerk 1748, vol.2, pp.1060-3), Hamburg (Beukemann 1912, pp.545-61), Leipzig (Moltke 1939, p. 14f., and Nuremberg (Roth 1802,p.338) private intermediaries who acted as matchmakers were temporarily tolerated and then forbidden again.

[23]Such an obligation was typically only temporary, and for select goods. A permanent obligation to use a broker as an intermediary can be documented in Brugge (see Gilliodts van Severen 1881), but is the exception and not representative for our sample.

by the merchants and the transaction was completed. The basis for calculating this fee varied. The most common was a fixed fee per unit traded, which we code as *unit fees*. Also common were fees which depended on the price paid. These were most commonly a simple percentage of the transaction price, but were sometimes nonlinear or step functions. We code all of these as *value fees*.[24]

When brokers were prohibited from conducting private business, we code this regulation as *private business constraint*. This constrained the brokers from making profits, acting as a private buyer, being in open and silent partnership with others, or working on commission for non-present merchants. Brokers were also often forbidden from being a host for their customers.

Although the observed sources are somewhat fragmentary, we can still document not only individual regulations, but also combinations of regulations that often appeared together. Many towns implemented a dominant design where they only gave a few licensed brokers the matchmaking right; these brokers did not have a right to conduct private transactions; merchants were free to use the matching service or transact on their own without a broker; and brokers were compensated with predetermined fixed fees, either unit fees or value fees as discussed above. We code these combinations of regulations as *matchmaking*; and more specifically, as *matchmaking with unit fees* and *matchmaking with value fees*, respectively.[25]

In a smaller number of regulations, brokers were not prohibited from conducting private business on their own behalf, but the other regulations were the same – brokerage was limited to a small number of licensed brokers, merchants could choose whether to use a broker, and brokers received fixed unit or value fees. We code this combination of rules as *matchmaking without private business constraint*. While this combination of rules has a flavor of intermediaries who act as market makers (i.e., brokers could have acted as re-sellers on a permanent basis), no such activity of official brokers can explicitly be documented from the sources.[26] In another, less common combi-

[24]We also introduce the category *fixed fees* which indicates any type of fixed, pre-specified fee. Here we find in total 695 observations in 50 towns. The numbers of fixed fees do not exactly equal the sum of unit and value fees, since a few sources reveal information on the existence of fixed fees but do not inform us of their exact nature, and in some cases we find both types of fees in one observation.

[25]Again, the numbers in table 1 for the matchmaking mechanisms with different fees do no exactly aggregate up to the category *matchmaking*, for the reason described earlier.

[26]Outside our period of investigation, during the 18th century, official brokers who acted as market makers can be documented – see van Bochove (2013) and Santarosa (2013). Thus, the relaxation of the private business constraint which we document, particularly later in our sample, might have been the starting point for such a movement and/or also the toleration of private intermediaries during the 17th century in selective cities as already previously outlined.

nation of rules, merchants were *required* to use a broker, while the other regulations (only licensed brokers, no private business, and fixed unit or value fees) remained the same; we code these as *forced matchmaking*. Even less common were regulations which did not specify a fixed level of fees (*matchmaking without fixed fees*), but where the other dominant rules remained the same.

Looking more closely at when and where these combinations of regulations were used, we see that the *matchmaking* rules described above were not only the most frequently-documented set of regulations, but also tended to be used in larger cities. (See table 1, column 5.) It was commonly used among the cities along one of the most important trade axes of the area and period of investigation, the catchment area of the Rhine/Main up to the Rhine-Meuse-Scheldt delta (Irsliger 2010) – see map 5a. Such a pattern can not only be documented on the aggregate level, but also during particular periods and for specific products – for instance, for wine between 1350 and 1400 (see map 5b).[27] The dominant matchmaking rules were also more frequent in sea port cities (see table 1, column 8); sea port cities typically had stronger trade intensities than other cities, but we cannot generalize this for cities at navigable rivers (see column 7). Finally, the average year in which the *matchmaking* rules were found is a slightly before, but rather close to, the average year of the whole sample. On the other hand, the less-frequently-documented *forced matchmaking* design tends to be found earlier, and the *matchmaking without private business constraint* design tends to be found later (see column 3).

3.2 Policy Goals

Many towns explained their motivations in regulating brokerage with short policy statements at the beginning of the regulations. Most of these policy statements were based around one of five broad goals:

- To promote and facilitate trade
- To reduce damage in trade for the merchants
- To benefit the town
- To benefit the citizens

[27] Such clear use of the matching mechanism along trade routes can also be documented for other products. However a comprehensive quantification is due to the fragmented nature of the data not possible.

- To ensure equal treatment of all merchants (locals and foreigners, rich and poor) by brokers

Table 2 shows how many times each of these explanations appeared in the regulations we found. (We code these five arguments as *promote facilitate trade*, *create order reduce damage*, *for the citizens*, *for the town*, and *equal treatment*.)

Typically, none of these explanations came with more detailed explanations. However, the goals are clearly in line with what has been described in the literature on medieval town policy and trade (Hibbert 1967). Cities had two basic, partly opposing interests. On one hand, they had an interest in ensuring a basic supply of consumption goods to the local population, and in providing the local craft industry with raw and semi-finished input goods, at reasonable prices. On the other hand, to guarantee such an inflow of products, towns had to offer foreign merchants attractive markets, with favorable allocation mechanisms guaranteeing them a certain share of the surplus from trade; otherwise merchants would go elsewhere. For regulations including the most frequently-observed combination of rules, we also observe a greater likelihood of mentioning these policy statements than in typical regulations (see table 2). Thus, it is natural to ask whether the observed brokerage regulations, in particular the dominant *matchmaking* combination, did indeed create allocation mechanisms which made these markets sufficiently attractive for both buyers and sellers, locals and foreigners.

4 Theory

4.1 Model

In this section, we lay out a simple stylized model to illustrate the effects of brokerage, distinguish between two types of compensation schemes for brokers, and understand the purpose of some of the other restrictions on broker behavior.

For now, we abstract away from the strategic details of bargaining between buyers and sellers, and from the buyers' concerns about whether or not to reveal their preferences truthfully to the broker, in order to focus on one particular effect: the broker's role in determining which buyers match with which sellers, the way this responds to the broker's incentives, and the effects that this has on trade. Our baseline model has the following elements:

Sellers

There are N sellers, who we will typically index by $j \in \{1, 2, \ldots, N\}$. Each seller has a single (indivisible) unit of a good for sale. The cost of seller j's good – or seller j's residual valuation for his unsold good – will be denoted c_j. Seller j knows c_j, but from the buyers' or the broker's point of view (or ours when we want to calculate expected surplus), c_j is a random variable.

Buyers

There are also N buyers, who we will typically index by i. Each buyer can consume at most one good. We will let $v_{i,j}$ denote the value buyer i gets from seller j's good. Buyer i knows his valuation for each good, but from the seller's point of view (and from ours when we want to compute ex ante expected surplus), it is a random variable.

Bargaining

To focus on the role of the broker in facilitating "better" matches, we abstract away from the details of buyer-seller bargaining and the risk of impasse. Instead, we will assume that bilateral bargaining is efficient – when a seller with cost c negotiates with a buyer with valuation v for that seller's good, trade occurs whenever $v > c$, and occurs at price

$$p = \phi c + (1 - \phi) v$$

(This is the solution to the Nash bargaining problem $\max_p (v - p)^{\phi} (p - c)^{1-\phi}$.)[28]

Although we model the bargaining outcome in a simple way, we also assume that bargaining is time-consuming enough that players cannot attempt to bargain with multiple partners. Once a buyer and seller pair up and begin to negotiate, if they fail to reach a deal, we assume neither one can negotiate with anyone else.

In the absence of a broker, we assume that the buyers and sellers would pair up randomly, with each randomly-determined pair negotiating among themselves and trading if trade is efficient. This

[28] This outcome with $\phi = \frac{1}{2}$ was proposed by Nash (1950, 1953), who showed it uniquely follows from a particular set of axioms. Binmore, Rubinstein and Wolinsky (1986) discuss the use of this model as a "reduced form" for more complex dynamic bargaining games. Here, we can think of ϕ as representing the two sides' relative bargaining strengths; this could be thought of as a reduced form for factors excluded from our model, such as the relative number of buyers and sellers or the likely time until the arrival of other merchants selling similar goods.

is the benchmark we compare to.

Broker

We assume that the broker knows the buyers' preferences $\{v_{i,j}\}$, but not the seller costs $\{c_j\}$. We make this assumption because the broker typically came from the same town as the buyers, and would interact with the same buyers repeatedly over a long period, while the sellers were typically traveling merchants from outside. (As we discuss later, however, our main result still holds if the broker has imperfect knowledge of $\{v_{i,j}\}$ for some or all of the buyers.)

Thus, we assume the broker knows $\{v_{i,j}\}$ and the distribution of each seller's costs, and chooses which seller to send each buyer to. We assume that the broker chooses the matching that maximizes the expected value of the commissions he earns, which will be determined as a function of the bargaining outcomes.

Note that given our assumptions – that bargaining outcomes are efficient, and that the broker knows the buyers' true preferences – we are really looking exclusively at the incentives facing the broker, and in some sense he is the only strategic player we consider.

Other details of the model

The other details of what we assume in our model:

- The broker's compensation is assumed to determine his behavior, but we do not explicitly deduct that compensation from the gains from trade. This is a reasonable approximation when the broker's commission is small relative to the gains from trade.

- We assume c_j is independent of $\{v_{i,j}\}$, and drawn from the uniform distribution on some interval $[0, A_j]$; we allow A_j to be different for different sellers, reflecting the fact that the sellers may offer goods of different "sizes".

- We assume that the bargaining parameter ϕ is common across all buyer-seller pairs, so that in every buyer-seller pair, the buyer captures the same fraction of the gains from trade. (Thus, ϕ can be thought of as reflecting general market conditions, not individual skill at bargaining.)

Our results will hold for any distribution of buyer valuations $\{v_{i,j}\}$, but we will assume $v_{i,j} \sim U[0, A_j]$ for numerical examples. We do not assume independence across $\{v_{i,j}\}$, and instead allow for unrestricted correlation among valuations – this will be discussed more below.

Note that Theorem 1 is proved theoretically (in Appendix A), but the numerical results in this section were calculated by simulation.

4.2 The Value of Brokerage

By assumption, in the absence of a broker, buyers and sellers pair up randomly and then negotiate à la Nash. This means that as the market size N grows, there is no increase in the expected surplus per player, as each buyer is still negotiating with only a single, randomly-chosen buyer.

On the other hand, a broker who knows the buyers' valuations can determine which possible matching of buyers to sellers creates the greatest expected surplus. As N grows, there are more potential matchings, and therefore more expected surplus generated by the "best" matching.

Figure 1 illustrates this difference. The figure assumes the products are symmetric ($A_j = A_{j'} = 100$) and buyer valuations are independent and uniform. The red dots represent the situation with no broker – as N increases and buyers and sellers match randomly, expected surplus per player remains constant. The blue diamonds represent the situation with a broker – under the assumption that he matches buyers and sellers to maximize the expected number of trades (as he would do under unit fees, discussed below).

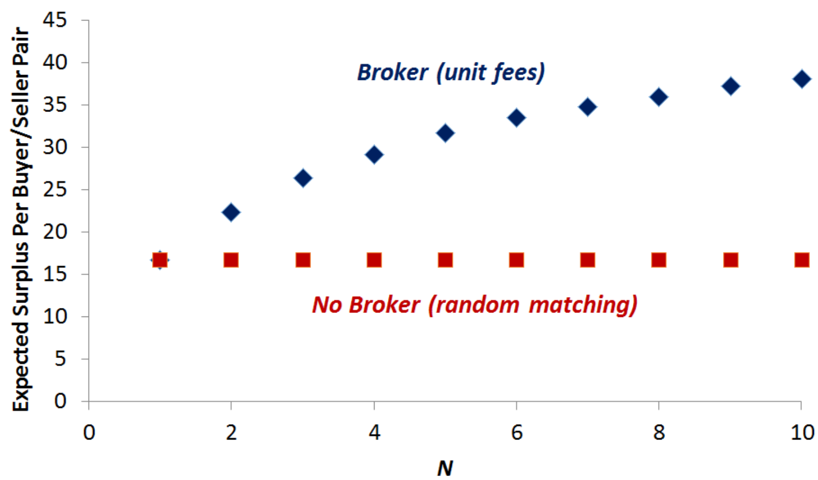
In this example, when $N = 2$, using a broker increases expected surplus by one third; when $N = 6$, using a broker doubles expected surplus. (The gain from using a broker would be lower, however, if buyer valuations were correlated.)

4.3 Unit vs Percentage Fees

Next, we explore the two dominant ways that brokers were compensated, and the tradeoff between the two.

Historically, the two dominant rules used to compensate brokers were a fixed commission for each unit traded ("unit fees") and a fixed percentage of the price of each sale ("percentage fees"). (Other less common rules included step functions or percentages which changed as the price increased, but

Figure 1: Gains from trade for different market sizes – broker vs. no broker



these two were by far the most common.) Next, we evaluate the outcomes each of these rules generate, to understand what conditions favor one rule or the other.

Baseline Result

Given the assumptions of our model, we can be surprisingly clear about which form of compensation leads to superior outcomes.

Theorem 1. *Under the model defined above, percentage fees lead to the highest expected payoffs, to both buyers and sellers, out of all possible compensation schemes.*

This result, of course, depends on the assumptions of our model – in particular, that seller costs are uniformly distributed (although we discuss relaxing this discussion later).[29] Nonetheless, it suggests that as a benchmark, we might expect percentage fees to often be optimal. A reasonable question, then, is why would we instead see unit fees much of the time, particularly early on?

The first part of the reason is that under some conditions, Theorem 1 notwithstanding, the difference in performance between unit and percentage fees is very small. For example, when

[29]The reason Theorem 1 holds is that when buyer i pairs with seller j, the expected payoff to buyer i, the expected payoff to seller j, and the expected commission earned by the broker under percentage fees are all proportional to $v_{i,j}^2/A_j$. Thus, by choosing the match that maximizes his expected commission – by maximizing $\sum_{i,j} v_{i,j}^2/A_j$ over all buyer-seller pairs (i,j) who match to each other – the broker also inadvertantly maximizes the expected surplus of all the buyers, as well as the expected surplus of all the sellers, over all possible matchings of buyers to sellers. Later on, we discuss other extensions under which the same result holds.

$N = 2$, $A_1 = A_2$ (the two sellers are offering products that are the "same size"), and buyer valuations $\{v_{i,j}\}$ are all independent and uniformly distributed as well, the expected increase in total surplus from switching from unit fees to percentage fees is less than 1%. This suggests that if there are other countervailing forces favoring unit fees, the sacrifice in theoretical performance may be overwhelmed by other forces. On the other hand, there are conditions under which percentage fees outperform unit fees by a more significant amount, and therefore even if other arguments favored unit fees, the improvement in performance from adopting percentage fees might be worth it.

First, then, what forces favor unit fees?

What favors unit fees: strategic information disclosure

In our model, we assume that the broker (knowing the buyers' preferences) chooses the matching of buyers to sellers to maximize his own expected fees, but does not do anything else to influence bargaining outcomes. In particular, we assume that he does share any information about the buyer's willingness to pay with the seller.

In fact, as noted above, many towns had explicit rules barring the broker from sharing any private information about either the buyer's or the seller's preferences with the other side. This suggests that such disclosure might have been a concern. Under unit fees, the broker is obviously concerned with maximizing the probability of trade. Under our assumption of Nash bargaining, trade occurs whenever it is feasible, so the broker does not gain anything by interfering further. (Under a different model of buyer-seller bargaining, the broker might be able to increase the likelihood of trade by disclosing some information, but it's not clear whether this would favor the buyer, the seller, or both.) On the other hand, under percentage fees, the broker benefits from driving up the price at which trade occurs, which could likely be accomplished by letting the seller know when the buyer has a particularly high willingness to pay. Thus, strategic behavior by the broker is likely more of a concern under percentage fees.

Making things worse, if buyers are aware that the broker has an incentive to try to influence bargaining outcomes toward higher prices, this would likely inhibit the broker's ability to learn the buyers' valuations truthfully. We did not formally model the broker learning these valuations – we assumed that because the broker came from the town and the buyers were typically the local residents, the broker likely interacted with the buyers frequently and could learn their tastes over time – but if the buyers suspect the broker has an incentive to tell the sellers when they are particularly eager to buy, this would create an incentive for buyers to deliberately misrepresent their preferences to the broker. This would interfere with the broker's ability to increase surplus by matching the right buyer to each seller. And again, this would be more of a concern under percentage than under unit fees.

(Brokers were also typically forbidden from participating in the market themselves – another situation where they could take advantage of information about buyers' willingness to pay, and therefore another possibility that might reduce buyers' willingness to share that information.)

Percentage fees also have one additional complication. If the broker is not physically present when the buyer and seller negotiate the sale, he relies on them reporting the price to him and paying the commission honestly. Under percentage fees, the buyer and seller could both benefit from under-reporting the price paid.[30] Under unit fees, as long as they can't hide that a transaction has taken place, there is nothing else to hide.

Thus, in settings where strategic, potentially unsavory behavior by the broker is more of a concern – or where mistrust of the broker might lead buyers to hide their true preferences – brokerage with percentage fees may not work as well as the model suggests, and unit fees might therefore be preferable.

In addition, even when these concerns are quite small, unit fees might still be preferable when the theoretical gains in performance from using percentage fees are particularly small – the question we explore next. When the theoretical gains from using percentage fees are large, they are more likely to overcome the disadvantages of strategic behavior.

Thus, the next question we explore is when the gains in match quality from using percentage fees are larger or smaller.

When are percentage fees most beneficial: correlation among buyer valuations

We noted above that Theorem 1 holds for any distribution of buyer valuations $\{v_{i,j}\}$ – including any structure of correlation. Next, we consider the effect that correlation among valuations has on

[30] In many U.S. states, state sales tax is collected when used cars are sold from one private party to another; buyers and sellers routinely write the formal purchase contract for less than the actual price, to reduce the tax owed.

the *magnitude* of the difference in performance between unit and percentage fees. We address this via simulation, focusing on the case of $N = 2$, with $A_1 = A_2 = 1$, and $v_{i,j} \sim U[0,1]$, but allowing for both correlation across the same buyer's valuation for different products, and correlation across different buyers' valuations for the same product. (If the same buyer's valuation for different sellers' products are positively correlated, this suggests some buyers are simply more eager than others to buy something. In the extreme case – perfect correlation – the products are identical, but each buyer attaches a different value to getting *any* of them. If different buyers' valuations for the same seller's product are positively correlated, this suggests there is a quality component to the products, with some sellers offering "better" products than others. In the extreme case, the buyers are identical, but the products differentiated vertically. We allow for both types of correlation, in arbitrary degrees; but under the latter interpretation, we implicitly assume that the "quality" component is independent of the seller's cost c_j.)

To see the effect of correlation on the relative performance of percentage and unit fees, we generated correlated valuations with uniform marginal distributions as

$$v_{i,j} = \Phi\left(\sigma_b \cdot \xi_i^b + \sigma_s \cdot \xi_j^s + \sqrt{1 - \sigma_b^2 - \sigma_s^2} \cdot \varepsilon_{i,j}\right)$$

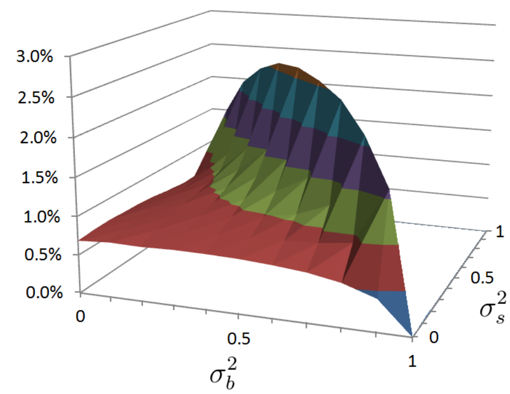
where $\{\xi_i^b\}$, $\{\xi_j^s\}$, and $\{\varepsilon_{i,j}\}$ are all independent draws from a standard normal distribution and Φ is the standard normal CDF.[31] $\{\xi_i^b\}$ can be thought of as a buyer-specific effect (buyer i's eagerness to buy any product), $\{\xi_j^s\}$ a "seller-specific" effect that applies to all buyers (the quality of product j), and $\{\varepsilon_{i,j}\}$ an idiosyncratic taste term specific to the buyer-seller pair; σ_b then reflects the degree of heterogeneity across buyers, and σ_s the degree of heterogeneity across products, while $\sqrt{1 - \sigma_b^2 - \sigma_s^2}$ reflects the importance of idiosyncratic preferences.

Using these valuations, we calculate expected total surplus for each buyer-seller pair when $N = 2$, continuing to assume that the broker matches buyers to sellers to maximize either expected unit fees or expected percentage fees, and calculate the difference. Figure 2 shows the increase in surplus from using percentage rather than unit fees for different values of σ_s and σ_b.

[31]Since ξ_i^b, ξ_j^s, and $\varepsilon_{i,j}$ are independently distributed $N(0,1)$, $\sigma_b \cdot \xi_i^b + \sigma_s \cdot \xi_j^s + \sqrt{1 - \sigma_b^2 - \sigma_s^2} \cdot \varepsilon_{i,j}$ has a normal distribution with mean $\sigma_b \cdot 0 + \sigma_s \cdot 0 + \sqrt{1 - \sigma_b^2 - \sigma_s^2} \cdot 0 = 0$ and variance $\sigma_b^2 + \sigma_s^2 + \left(1 - \sigma_b^2 - \sigma_s^2\right) = 1$; so $\Phi\left(\sigma_b \cdot \xi_i^b + \sigma_s \cdot \xi_j^s + \sqrt{1 - \sigma_b^2 - \sigma_s^2} \cdot \varepsilon_{i,j}\right)$ has distribution $U[0,1]$, consistent with our modeling assumption.

Figure 2: Gain from using percentage over unit fees – $N = 2$, $A_1 = A_2$, correlated valuations

		σ_b^2 0	0.25	0.50	0.75	1
	0	0.7%	0.7%	0.7%	0.6%	0.0%
	0.25	0.7%	0.9%	1.1%	**2.3%**	
σ_s^2	0.50	0.7%	1.1%	**2.6%**		
	0.75	0.6%	**2.3%**			
	1	0.0%				



Result 1. *As Figure 2 illustrates, the gain from using percentage rather than unit fees...*

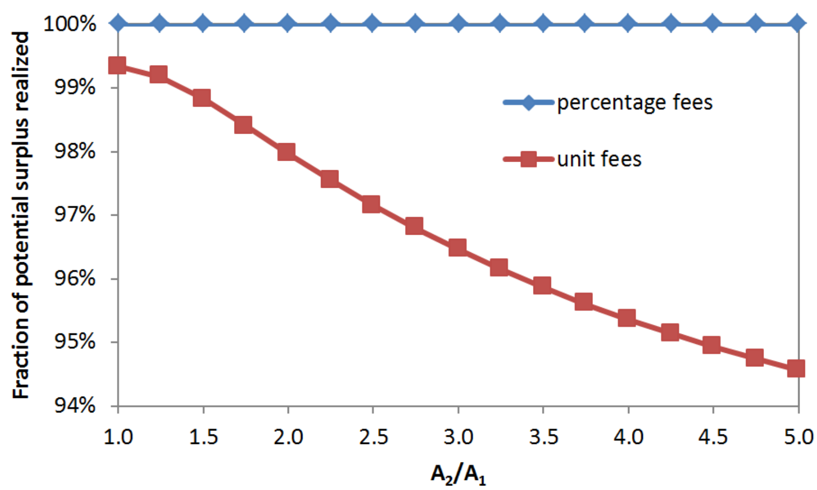
- *...is largest when there is heterogeneity of both types – both among buyers (some are more eager than others)* and *among sellers (goods of different quality levels).*
- *...is smallest when either the products are identical (so that $v_{i,j} = v_{i,j'}$, which implies $\sigma_b = 1$) or the buyers are identical (so that $v_{i,j} = v_{i',j}$, which implies $\sigma_s = 1$)*
- *...but is also small when there is little heterogeneity overall, so that most of the variation is idiosyncratic ($\sigma_b \approx \sigma_s \approx 0$)*

When are percentage fees most beneficial: asymmetric products

Our simulations for correlation assumed that $A_1 = A_2$ – that in some sense, the two products were of equal importance or equal size. If there is asymmetry across the different products, this makes percentage fees more valuable. The logic is simple: a broker facing unit fees puts equal weight on the likelihood of each product trading, while "larger" products typically create more surplus when they trade.

Figure 3 illustrates this, again for the case of $N = 2$, and this time with independent $\{v_{i,j}\}$, showing how much of the available surplus each fee structure achieves as the degree of asymmetry across products varies. When the products are symmetric ($A_1 = A_2$), percentage fees are optimal, but unit fees still achieve 99.3% of the available gains from trade. As the products get more asymmetric (A_2/A_1 grows), percentage fees remain optimal, while the performance of unit fees relative to percentage fees decreases. The pattern for $N = 3$ is identical, with a very slightly larger difference in performance between percentage and unit fees, particularly as the asymmetry gets larger.

Figure 3: Fraction of potential surplus captured under each type of commission – $N = 2$, independent valuations



Result 2. *As Figure 3 illustrates, the gain from using percentage over unit fees gets larger as the products get more asymmetric in size.*

4.4 Departures From Our Baseline Model

Broker doesn't know all buyers' valuations

Our primary model assumes that the broker has knowledge of all the buyers' preferences, motivated by the fact that in most cases, the buyers were local merchants while the sellers were often foreigners. However, over time, foreigners came to sometimes buy through the brokers as well, introducing the possibility that the broker might not have been as likely to exactly know all the buyers' exact preferences.

As it happens, this does not change the result of Theorem 1. If the broker knew some buyers' valuations exactly, but knew others' only approximately, or not at all – instead just knew the probability distribution they were drawn from – then percentage fees (with the broker maximizing his expected commissions in the face of this uncertainty) would still lead him to choose the best possible matching of buyers to sellers. Theorem 1 – the optimality of percentage fees – holds for whatever amount of information the broker has about buyer valuations.

Other models of buyer-seller bargaining

In our primary model, we assume that buyer-seller bargaining is efficient, à la Nash. Within that model, we can still vary the relative bargaining power of buyers versus sellers, by varying the parameter ϕ representing the share of the gains from trade captured by the buyers.

However, as an extension, we can also consider what would happen under a different model of bargaining, where "bargaining power" is modeled in a different way. We consider an alternative where one of the two parties makes a take-it-or-leave-it price offer to the other; the party receiving the offer can either agree to trade at that price, or reject the offer, in which case the two parties don't trade. In this model, bargaining is not efficient – there is some chance trade will not occur even when the buyer's valuations is above the seller's cost, due to strategic behavior on the part of the party making the offer. In general, this mechanism is optimal from the point of view of the party making the offer, so we can think of that party being the one with greater bargaining power.

In Appendix A, we analyze the effect of brokerage, and of the different compensation rules for brokers, under this model. Maintaining the other assumptions of our model as described above, we find the following:

1. When it is the buyers who have greater bargaining power (buyers make price offers), just as in our baseline model, percentage fees are always optimal for both sides of the market.[32]

2. When it is the sellers who have the bargaining power, subject to an additional simplifying assumption explained in Appendix A...

    - Unit fees maximize total surplus when the products are symmetric ($A_1 = A_2 = \ldots = A_N$), but percentage fees give higher expected surplus to buyers

[32] As in the case of Nash bargaining, this is because when buyer i matches to seller j with $c_j \sim U[0, A_j]$ and the buyer makes a take-it-or-leave-it offer, the buyer's expected surplus, the seller's expected surplus, and the broker's expected commission are all proportional to $v_{i,j}^2/A_j$, so the matching of buyers to sellers that maximizes the broker's commissions also maximizes expected payoffs to each side of the market.

- When the products are asymmetric, neither unit nor percentage fees are optimal, and percentage tend to outperform unit fees unless the degree of asymmetry across products is very small

Different distributions of seller costs

Theorem 1, and our numerical results above, are all based on the assumption that $c_j \sim U[0, A_j]$, i.e., that the distribution of each seller's costs is uniform. Under other distributions of seller costs, however, percentage fees may not be optimal anymore. In Appendix A, we show that Theorem 1 still holds for a slightly more general family of distribution functions, but it is certainly not universal; under other cost distributions, percentage fees would no longer be optimal, and unit fees might yield the higher surplus of the two.

4.5 Overall takeaway

Theorem 1 says that when the broker is able to truthfully ascertain buyer preferences, percentage fees will always outperform unit fees. However, we noted that unit fees may be more likely to prevent strategic information disclosure by the broker, and therefore more likely to elicit truthful communication between buyers and the broker; so unit fees may be preferred when the theoretical gains from using percentage fees are small. Those theoretical gains are small when products are similar or identical, larger when products are asymmetric in size and when there is heterogeneity both across buyers and sellers (products). The overall takeaways from our theoretical analysis are the following.

- Brokers create value by improving the matching between buyers and sellers, increasing the surplus realized by both sides of the market.
- Unit fees are more likely to be optimal when strategic behavior by brokers is a concern, and when the products are are very similar or standardized ($A_j = A_{j'}$ and $\sigma_s \approx 0$).
- Percentage fees are more likely to be optimal when products are very asymmetric in size ($A_j \neq A_{j'}$), or when there is heterogeneity both across buyers and across products.
- If we depart from the Nash bargaining assumption and instead consider take-it-or-leave-it

price offers, unit fees are more likely to be optimal when the products are symmetric and sellers have more bargaining power; while percentage fees are more likely to be optimal when either products are asymmetric or buyers have more bargaining power.

5 Empirics and Discussion

5.1 Where Was Brokerage Used

We begin by investigating which cities instituted brokerage at all, and how they compare with the cities that did not. The model predicts that brokerage will always offer an increase in allocative efficiency, but that this improvement can be larger or smaller depending on the size of the market and the characteristics of preferences, so different cities will face different incentives with regard to whether to institute brokerage and how to do so. To create a variable which approximately indicates whether brokerage was used in a town, we divide our period of investigation (1200-1700) into 50 year intervals, creating potentially ten time windows for each of the 227 cities. However since some cities were only founded over time this results in 1823 observations (from 2270 potential observations). We create a binary variable for each of 1823 city/time observation, which is 1 if we find brokerage regulations mentioned at least once in that time period, and 0 otherwise. We then examine whether this variable is correlated with various demographic, political, and trade-geographic variables.[33]

Table 3 shows descriptive statistics, and table 3a shows related statistical significance tests, when we compare characteristics of cities with brokerage to cities without. (Table 3a shows paired t-tests comparing the mean of a variable in cities with and without brokerage, and Chi2 tests investigating the statistical relationship between binary variables and the constructed brokerage variable.) We find evidence that cities with trade-geographic advantages seem more likely to have implemented brokerage regulations. Cities with access to the sea, and with more trade routes (counting all routes entering a city from the land, river, or sea), were more likely (statistically significantly) to have implemented brokerage.[34] In addition, the average population size of a city

[33] Due to the fragmented nature of the data, the large number of binary variables, and endogeneity of the different explanatory variables, we stick to descriptive statistics and simple statistical tests, rather than more advanced econometric techniques. However, we can replicate the results presented in this section with probit regressions using the existence of brokerage as dependent variable; the results are in line in both sign and statistical significance with what we present here, and continue to hold when we cluster the error terms by cities. Results are available on request.

[34] For an identification of seaport towns, towns at navigable rivers, and number of trade routes entering a city see Putzger 1956, p.70

with brokerage is significantly higher than for cities without brokerage regulations. (This difference in population size and number of trade routes also holds if we look into different sub-groups of cities, grouping them along political characteristics.)

Looking at the political characterization of the cities, we observe that Free and Imperial cities more commonly implemented brokerage.[35] Bishop cities were not significantly more likely to implement brokerage, and cities with a territorial duke were less likely to implement brokerage. This can be understood in the following way. Bishop and territorial cities could rely on a broad range of rents and taxes, while free and imperial cities did not have access to such income streams and therefore needed to succeed as production and merchant cities, giving a greater need to create a functioning market platform to support trade. In addition, in these cities, local merchants and craftsmen participated in the local government, and could directly influence the organization of markets. Thus, cities with more political and economic freedom tended to implement market making regulations (Acemoglou et al. 2005b).

We do not find that belonging to the Hanseatic League had a differential effect on a city instituting brokerage.[36] This might seem surprising at first, since we would expect that cities who organize their trade political interests abroad would also organize the markets inside the town walls. However, scholars of the Hansa (Dollinger 1966, Friedland 1991) argue that cities belonging to the Hanseatic League were rather heterogeneous and not all of them were necessarily so actively involved; thus, membership is not such a strong indicator of trade activities *per se*.[37] Finally, we find a strong significant relationship between the implementation of brokerage and the existence of a university in a city.[38] This is in line with Cantoni and Yuchtman (2014), who argue that universities produced experts who were able to read and write and in this way could be instrumental

[35]The political organization of a city can be characterized in the following way (see Isenmann 1988). There were "territorial towns" which were controlled by a local duke. There were "bishop towns" which were under the rule of an ecclesiastical leader. Finally, there were "free cities" and "Imperial cities," which are labeled in the literature as "Free Imperial cities." Imperial cities were directly ruled by a local consulate representing (some of) their citizens, but were formally under the legal protection of the German Kaiser (who had normally only limited influence on the political decision making of a town). Free cities also had only the German Kaiser as political head, but liberated themselves from the control of the bishop. (See Heining 1983, Johannek 2000.) For the identification of Free and Imperial cities, see Johanek (2000); for the bishop cities, see Bautier et al. (1977-1999). The remaining cities are considered territorial. We could alternatively have assigned the Dutch cities after the successful revolt in 1579 to the group of Free and Imperial cities, but the results would not have changed.

[36]Cities which joined the Hanseatic League can be found in Dollinger (1966).

[37]However, among the cities in the Hanseatic League, if they implemented brokerage at all, they tended to choose a sophisticated design, as discussed below.

[38]University cities can be found in de Ridder-Symoens and Rüegg (1992-2011).

in implementing market regulations.

5.2 Matching Mechanism with Unit or Value Fees

As we noted above, many cities that implemented brokerage used a particular, dominant combination of rules: a small number of brokers were licensed to act as intermediaries but sellers were free to use them or find deals on their own; brokers were prohibited from participating in the business in other ways; and fees were fixed in proportion to either the volume traded (unit fees) or the price paid (value fees). In the theory section, we found that the gain from using value fees instead of unit fees increases when products differ in size or preferences are heterogeneous. When product size and preferences are homogeneous, then both type of fees generate very similar outcomes, while unit fees help to reduce other "bad" incentives which could negatively impact the allocation process. Among the cities that implemented the dominant "matchmaking" brokerage design, we can investigate the choice of unit versus value fees, and see whether it seems in line with our theoretical predictions.[39]

One major pattern we observe is that certain product genres tended to favor one or the other type of fees. Table 4 column 7 shows the share of designs associated with each product genre and Fisher's Exact significance test (column 8) between these two binary variables. (Table 4 columns 4 and 5 also show the choice of unit versus value fees among all regulations with fixed fees, regardless of the other rules in place. We feel focusing on those cities with otherwise-similar regulations is more informative. However for the simpler differentiation of fees we have more observations and both statistics depict similar and consistent results.)

Three products were traded much more frequently (statistically significantly) via brokerage using value fees: horses, property, and financial products. Horses and properties are very idiosyncratic products by nature, and especially for the latter there would be strong differences in size. Financial instruments, for example bills of exchange, were also very heterogeneous, as preferences for them depended very much on the participants and the place the bill was drawn on. The limited tradeability of bills of exchange made the valuation even more heterogeneous (van der Wee 1963, North 1981, Munro 1994). Of course we can also expect big differences in size for financial products. Thus, the choice of fee structure for these types of products is in line with the theoretical

[39] Again, we stick to descriptive statistics and simple statistical tests, but the results are the same if we were to use probit regressions and cluster error terms by city.

predictions of the model, which finds value fees producing higher gains than unit fees for both sides of the market.

As we discussed in the theory section, however, with value fees, there could be a concern that buyers might be hesitant to reveal their true willingness to pay to the broker, for fear that this would inflate the price they would pay. As a possible remedy for this, we find evidence of the use of nonlinear percentage fees (in Cologne 1360, 1365, Stein II, 1893-5, pp.31-35), or percentage fees with upper limits (Bruinswick 1320, 1433: Hänselmann and Mack 1900, vol. 2, pp. 516-7 and vol. 3, pp. 143-4; Ofen 1413, Michney and Lichner 1845, pp.72-4) for horses. In these cases, a fixed percentage fee was applied up to a particular price, with either a lower percentage (half the original) or no additional fee applied beyond that price. This type of fee structure can be interpreted as a smoothing of the incentives of the broker not to aim for too high a price. The case of Cologne is of particular interest: in an earlier regulation from 1348 (Loesch 1907, p.122-6), percentage fees with limits were used, while from 1407 on (Stein II, 1893-5, pp. 178-81) simple percentage fees were applied. Thus, there may have been a "trial and error" process involved in finding the rules creating "right" incentives.

Distinct from the products above, we can look at a second group of products containing basic consumption goods like grain, wine and beer, fish, cattle and meat, oil and fat, which were rather homogeneous. (Only a small fraction of wine consumed was high quality wine, where we might expect more variations in value – see Kellenbenz 1986 and Matheus 2004.) Here, again consistent with theory, most of the products were traded more often with unit fees, and the relationships between product and fee structure are again mostly statistically significant. Similarly, the rather homogeneous raw input and construction materials such as wood, bricks, and metals were mainly traded via unit fees. This is in line with our theoretical predictions that for homogeneous goods, matching with unit fees produces similar outcomes to matching with percentage fees, and might be favored due to reduced incentives for brokers to favor higher prices. Such an economic policy corresponds with the historical literature, which argues that towns had to guarantee the supply of sufficient basic products such as foodstuff for reasonable prices to the local population (Hibbert 1967, pp. 161ff.).

Finally, there were some products which were commonly traded via both unit and value fees. Spices and similar goods such as coloring products fit this description, as do products for the clothing manufacturing "industry": raw textile inputs such as wool, linen, or fustian, (semi-finished) cloth, and also furs, skin, and leather products. In the first case, this might be surprising: different types of spices differed strongly in value, and we might also expect that buyers had fairly heterogeneous preferences, yet we frequently find regulations specifying both unit and value fees. However, it appears that towns followed two different kinds of strategies when it came to spices. In cases where unit fees were used, we find long detailed lists of spices, with a different unit fee assigned for each one. (One example is brokerage rules from Frankfurt 1373 – see Buecher 1915, p.250.) This reduced the heterogeneity within the category. On the other hand, when value fees were applied, only a generic expression for spices was mentioned, with a fixed percentage applying to all of them. (An example is rules from Ofen in 1403 – see Michney and Lichner 1845, p. 74; or Bruinswick in 1320, see Hänselmann and Mack 1900, vol. 2, pp. 516-7.)[40]

For cloth we can identify a similar strategy. In some cases, there were long lists for different types of cloth. (For example, see Brugge 1303 (Gilliodts 1881, pp.223-35), or Antwerp 1412 (Dillis 1910, pp.413-7).) On the other hand, sometimes there was just a generic expression for cloth and a specified percentage fee (Prague 1332 – see Rössler 1845, pp. 47; Bruinswick 1433, see Hänselmann 1900, vol. 3, pp. 143-4); and in some cases there were both. Again, the huge variety of cloth produced and the related heterogeneity of tastes can explain such a pattern. A rich literature on textile production and consumption (even following fashion cycles) documents such a pattern and supports this interpretation. (Werveke 1965, pp. 354-6; Parry 1967, pp. 173-215, Kellenbenz 1986, pp. 209-212, 214, Munro 1994, 1998, 2003)

More surprising is the frequent use of value fees for raw textiles and fur, skins, and leather products, as these products are rather homogeneous. Indeed, when these products are traded by unit fees, we rarely find longer lists of products with different fees as in the case of spices or cloth. We find one unit fee for a sack of wool (Cologne 1406, in Stein II, 1893-5, pp. 113f.), or one bale of fustian (Middleburg 1405, in: Pols 1888, p.597). Nevertheless, we frequently observe regulations specifying value fees. In the case of brokerage regulations from Bruinswick, we find a switch from unit fees (in 1320) to value fees (in 1433). One explanation might be that towns had an interest

[40]In some cities, particularly during the seventeenth century, we find a combination of both systems at work: long lists of products with unit fees, plus a group of products with percentage fees. (For Amsterdam, see Noordkerk 1748, pp.1060-1063; for Hamburg see Beukemann 1912, pp. 542-561.) In case we found both types of fees in one observation, we assigned this in the empirical analysis of table 3 to value fees.

to make the market platform attractive for the foreign seller side. The textile industry was very dynamic and rapidly growing during the middle ages and early modern time. For many cities in our sample, the textile industry was the most important production and export sector. Thus cities had a strong interest in promoting the inflow of raw textile products for further processing (Hibbert 1965, pp.172 ff., Munro 1990 and 2003, van der Wee 2003). Percentage fees might create incentives for the broker to encourage higher expected prices, again appealing to foreign merchants. Furthermore, the textile sector was often organized along guilds. Therefore the buyers could have exercised some local bargaining power. Our model indeed predicts that percentage fees lead to better outcomes for both buyers and sellers when it is the buyers who have the bargaining power. In contrast, recall that basic foodstuffs were mainly matched with unit fees. Food shortages could temporarily arise in cities, giving sellers more bargaining power; in the theory section, we found that when products are homogeneous and sellers have bargaining power, unit fees lead to better outcomes.

Aside from comparing different product genres, we can also investigate the link between the choice of unit versus value fees and the demographic, trade-geographic, and political city-variables considered above. The results can be found in table 4a for the binary variables, and in table 4b for the other variables. Overall, the results do not indicate very strong differences or statistically significant relationships. The population size (*population*) is roughly the same among cities using value fees and those using unit fees. There is no significant effect for cities along a river (*river port*) or at the sea side (*sea port*). We find some effects if we compare the number of trade routes: cities with value fees have on average a higher number of trade routes, and the relationship is statistically significant. The number of trade routes might indicate a higher intensity and complexity of trade; thus we might expect a higher heterogeneity of product markets in general, which would favor matching with value fees. The political organization of a city indicates some, but not such strong, effects. Bishop cities were more likely to have brokerage designs with unit fees; Free and Imperial cities and cities belonging to the Hanseatic League tended to have both types of fees. The latter two types of cities might have been involved in stronger trade activities: Hanseatic towns due to their foreign trade political engagement, and as noted above, Free and Imperial cities due to their greater reliance on production and trade in the absence of other income sources. Other variables which characterize the city such as university towns do not create any unambiguous results. Finally, matching with value fees seems to have been implemented significantly later in time than matching with unit fees. Again, this could be indicative of a higher intensity and complexity of trade, and therefore greater heterogeneity of products.

6 Conclusion

This paper studies the market microstructure of pre-industrial Europe. We examine brokerage as a market-clearing institution implemented by town officials in late medieval and early modern merchant cities. We show that matching mechanisms based on different brokerage rules were known and applied, and that the rules chosen were related to the properties of the goods being traded in a way that accords with economic theory.

To achieve these results, we created in the first step a comprehensive source analysis covering brokerage statutes from 70 towns north of the Alps in Central and Western Europe from the middle of the 13th century until the end of the 17th century based on an investigation of 227 cities. We identified brokerage as a centralized matchmaking institution implemented by towns to promote and support trade, to create welfare for the town and their citizens, and to give equal opportunities to the citizens and foreign merchants. In the second step we took the dominant brokerage design identified and placed it into the framework of a simple matching model, and compared the outcomes to outcomes based on random matching of buyers and sellers. We showed that the observed brokerage designs indeed improved welfare for both the buyer and seller side. We also showed that matching designs with different fee structures create different incentives for the matching broker, leading to different welfare properties depending on the properties of the product in question. In a third step we tested if the choice of brokerage regulations statistically relate to the different product markets observed in accordance with our predictions. We indeed found that we could observe greater use of value fees for products with more heterogeneous preferences and products, and greater use of unit fees for homogeneous product markets. Furthermore we showed that brokerage regulations were in general implemented in cities with trade-geographic advantages, larger populations, and stronger (political) economic interests. Finally, we documented a relationship between the implementation of brokerage and the existence of a university in a city.

These results highlight the active role of merchant cities in pre-industrial Europe in creating markets and in solving incentive and allocation problems. The driving force of these activities can be seen in the increase of trade and in stronger market integration, which created inter-market competition among merchant cities. These results support the argument that formal market institutions are related to further economic expansion and growth.

These results open up new questions for a future research agenda. This paper only covered one specific market clearing mechanism out of the set of medieval market rules. Other rules related to market location and the timing of buying and selling goods. It would be of considerable interest to examine the interplay of brokerage and other market mechanisms in pre-industrial markets. Another question relates to the evolution and learning behavior of market rules in merchant cities. A comprehensive set of market rules might enable us to study the learning behavior of cities in a long-run historical context. In addition, it would be interesting to link market making activities more explicitly to city growth, with the ultimate goal to understand divergence in growth paths.

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Appendix A Proof of Theorem 1 and Extensions

A.1 Preliminaries

For any given assumption about how buyers and sellers bargain with each other once matched, we can ask the same three questions:

1. Which matching of buyers to sellers would be chosen by a broker maximizing expected commissions under unit fees?

2. Which matching of buyers to sellers would be chosen by a broker maximizing expected commissions under percentage fees?

3. Which matching leads to higher expected payoffs?

We will do this by fixing a realization of buyer valuations $\{v_{i,j}\}$ – that is, the information the broker has when he decides which buyer to match to which seller – and considering the problem in expectation over the possible realizations of seller costs $\{c_j\}$. For a given bargaining assumption, we will define $T(v_{i,j}, j)$ as the probability that trade occurs when a buyer with valuation $v_{i,j}$ is matched to a buyer with cost $c_j \sim U[0, A_j]$, and $R(v_{i,j}, j)$ as the expected revenue from such an interaction – that is, the probability of trade times the expected price. If we let σ denote a matching of sellers to buyers, such that buyer $\sigma(j)$ matches to seller j, then a broker earning unit fees would maximize his own payoff by choosing the matching that solves

$$\max_{\sigma} \sum_{j=1}^{N} T(v_{\sigma(j),j}, j)$$

and a broker earning percentage fees would maximize commissions by solving

$$\max_{\sigma} \sum_{j=1}^{N} R(v_{\sigma(j),j}, j)$$

Finally, we let $TS(v_{i,j}, j)$ denote the expected surplus generated by the buyer-seller pair, again given the realization of $v_{i,j}$ but in expectation over c_j; and $B(v_{i,j}, j)$ and $S(v_{i,j}, j)$ the buyer's and seller's expected surplus, respectively.

A.2 Baseline model: buyers and sellers Nash-bargain

For Theorem 1 in the text, we suppose that when a buyer with valuation $v_{i,j}$ meets a seller with cost c_j, the players Nash-bargain – trade occurs whenever $v_{i,j} > c_j$, at price $p = \phi c_j + (1-\phi)v_{i,j}$. In that case, given $v_{i,j}$ but in expectation over c_j, the probability of trade is

$$T(v_{i,j}, j) \quad = \quad \Pr(c_j < v_{i,j}) \quad = \quad \frac{v_{i,j}}{A_j}$$

and expected revenue is

$$\begin{aligned} R(v_{i,j}, j) &= \int_0^{v_{i,j}} (\phi c + (1-\phi)v_{i,j}) \frac{1}{A_j} dc \\ &= \frac{1}{A_j}\left(\frac{1}{2}\phi v_{i,j}^2 + (1-\phi)v_{i,j}^2\right) \qquad = \quad \frac{2-\phi}{2A_j} v_{i,j}^2 \end{aligned}$$

Total surplus is

$$TS(v_{i,j}, j) \quad = \quad \int_0^{v_{i,j}} (v_{i,j} - c) \frac{1}{A_j} dc \quad = \quad -\frac{1}{2A_j}(v_{i,j} - c)^2 \Big|_{c=0}^{v_{i,j}} \quad = \quad \frac{1}{2A_j} v_{i,j}^2$$

and the buyer's share is

$$\begin{aligned} B(v_{i,j}, j) &= \int_0^{v_{i,j}} (v_{i,j} - (\phi c + (1-\phi)v_{i,j})) \frac{1}{A_j} dc \\ &= \int_0^{v_{i,j}} (\phi v_{i,j} - \phi c) \frac{1}{A_j} dc \qquad = \quad \frac{\phi}{2A_j} v_{i,j}^2 \end{aligned}$$

leaving expected surplus of

$$S(v_{i,j}, j) \quad = \quad \frac{1-\phi}{2A_j} v_{i,j}^2$$

for the seller.

Since ϕ is assumed to be the same across all buyer-seller pairs and is therefore simply a constant,

$$\begin{aligned}
\arg\max_{\sigma} \sum_{j} R(v_{\sigma(j),j}, j) &= \arg\max_{\sigma} \sum_{j} \frac{2-\phi}{2A_j} v_{\sigma(j),j}^2 \\
&= \arg\max_{\sigma} \sum_{j} \frac{1}{2A_j} v_{\sigma(j),j}^2 = \arg\max_{\sigma} \sum_{j} TS(v_{\sigma(j),j}, j) \\
&= \arg\max_{\sigma} \sum_{j} \frac{\phi}{2A_j} v_{\sigma(j),j}^2 = \arg\max_{\sigma} \sum_{j} B(v_{\sigma(j),j}, j) \\
&= \arg\max_{\sigma} \sum_{j} \frac{1-\phi}{2A_j} v_{\sigma(j),j}^2 = \arg\max_{\sigma} \sum_{j} S(v_{\sigma(j),j}, j)
\end{aligned}$$

Thus, the match σ that maximizes expected commissions under percentage fees, coincides with the match that maximizes expected total surplus, as well as the match that maximizes expected surplus to all the buyers, and the match that maximizes expected surplus to all the sellers. So a broker earning percentage fees will always choose the match that both sides of the market would prefer. □

A.3 Extension: imperfect knowledge of some buyers' preferences

Suppose that the broker does not know exactly all buyers' valuations, and instead only knows the probability distribution of some of them. Pairing buyer i to seller j then creates expected surplus of $E_{v_{i,j}} \frac{1}{2A_j} v_{i,j}^2$, with the expectation taken with respect to the distribution of $v_{i,j}$ conditional on the broker's information. The buyer's expected surplus is $E_{v_{i,j}} \frac{\phi}{2A_j} v_{i,j}^2$, the seller's is $E_{v_{i,j}} \frac{1-\phi}{2A_j} v_{i,j}^2$, and the broker's expected commission is based on expected revenue $E_{v_{i,j}} \frac{2-\phi}{2A_j} v_{i,j}^2$. Now to maximize his expected commissions, the broker solves

$$\max_{\sigma} \sum_{j} E_{v_{\sigma(j),j}} \frac{2-\phi}{2A_j} v_{\sigma(j),j}^2$$

whose solution is also solution to $\max_{\sigma} \sum_j E_{v_{\sigma(j),j}} \frac{\phi}{2A_j} v_{\sigma(j),j}^2$ and $\max_{\sigma} \sum_j E_{v_{\sigma(j),j}} \frac{1-\phi}{2A_j} v_{\sigma(j),j}^2$. So once again, the broker is led to choose the matching that maximizes both expected total buyer surplus and expected total seller surplus.

A.4 Extension: take-it-or-leave-it price offers

Consider an alternate assumption about bargaining: once a buyer and seller pair up, one of the two makes a "take-it-or-leave-it" price offer to the other. (This is the most favorable bargaining mechanism available for whichever party gets to make the offer. Thus, we can think of that party being the one with all the "bargaining power".)

When it is the buyer who gets to make the offer, the same results hold as in the Nash-bargaining model:

Theorem 2. *Modify the primary model such that after the matching is chosen, each buyer makes a take-it-or-leave-it price offer to the seller he paired with. Percentage fees lead to the highest expected payoffs, to both buyers and sellers, out of any possible compensation scheme.*

Proof. Suppose that buyer i pairs with seller j. Buyer i values the seller's product at $v_{i,j}$, and believes that $c_j \sim U[0, A_j]$. By offering a price of $p \in [0, A_j]$, the buyer will trade with probability $\Pr(c_j < p) = \frac{p}{A_j}$, giving expected payoff $(v_{i,j} - p)\frac{p}{A_j}$. This is maximized at $p = \frac{v_{i,j}}{2}$, so the buyer will offer that price in equilibrium. As a result, the buyer will trade whenever $c_j < \frac{v_{i,j}}{2}$. This means that...

- The probability of trade is $T(v_{i,j}, j) = \dfrac{v_{i,j}}{2A_j}$
- If trade occurs, it happens at price $\dfrac{v_{i,j}}{2}$, so expected revenue is

$$R(v_{i,j}, j) \quad = \quad \frac{v_{i,j}}{2A_j} \cdot \frac{v_{i,j}}{2} \quad = \quad \frac{v_{i,j}^2}{4A_j}$$

- The expected surplus generated by the pairing is

$$TS(v_{i,j}, j) \quad = \quad \int_0^{v_{i,j}/2} (v_{i,j} - c)\frac{1}{A_j} dc \quad = \quad \frac{3}{8}\frac{v_{i,j}^2}{A_j}$$

- The buyer's expected surplus is

$$B(v_{i,j}, j) \quad = \quad \frac{v_{i,j}}{2A_j}\left(v_{i,j} - \frac{v_{i,j}}{2}\right) \quad = \quad \frac{1}{4}\frac{v_{i,j}^2}{A_j}$$

and the seller's surplus is therefore

$$S(v_{i,j}, j) \quad = \quad \frac{3}{8}\frac{v_{i,j}^2}{A_j} - \frac{1}{4}\frac{v_{i,j}^2}{A_j} \quad = \quad \frac{1}{8}\frac{v_{i,j}^2}{A_j}$$

Like in the Nash bargaining case, expected revenue $R(v_{i,j}, j)$, total surplus $TS(v_{i,j}, j)$, and each side's surplus $B(v_{i,j}, j)$ and $S(v_{i,j}, j)$ are all proportional to $\frac{v_{i,j}^2}{A_j}$, and so the match σ maximizing expected commissions under percentage fees – the match that solves

$$\arg\max_{\sigma} \sum_j \frac{v_{\sigma(j),j}^2}{A_j}$$

is the same match that maximizes expected total surplus, as well as expected surplus for each side of the market. □

The case where the sellers get to make the price offers is more complicated, for the following reason. When buyers make the price offers, being paired up with sellers selectively does not change the bargaining game: each buyer confronts a seller he believes has a cost $c_j \sim U[0, A_j]$, and therefore still offers a price $\frac{v}{2}$ to maximize his surplus. However, when sellers make the price offers, the matching of buyers to sellers effects bargaining: in equilibrium, a seller knows that he is not dealing with a "random" buyer with valuation $v_{i,j} \sim [0, A_j]$, but a buyer who was matched specifically to him and is therefore likely to have an above-average valuation. This makes the game very difficult to analyze: the broker's choice of how to match buyers to sellers influences the bargaining outcomes they reach, but the bargaining outcomes they will reach also influence the broker's choice of how to match buyers to sellers. In order to short-circuit this loop, we make the simplifying assumption that sellers ignore this selection when negotiating with buyers, and act as if they were facing a "random" buyer with valuation $v_{i,j} \sim U[0, A_j]$. We can think of this purely as a convenient simplifying assumption, as an assumption about limitations on seller sophistication, or as a way for the seller to not "punish" the broker (by reducing the likelihood of a sale by demanding a higher price) for sending him eager buyers. In any case, we will impose this assumption when analyzing the case where sellers make the offers.

Assumption 1. *When making price offers, sellers ignore selection and act as if facing a random buyer with valuation $v_{i,j} \sim U[0, A_j]$ rather than a selected buyer.*

Theorem 3. *Modify the primary model such that after the matching is chosen, each seller makes a take-it-or-leave-it price offer to the buyer he paired with. Assume valuations $v_{i,j} \sim U[0, A_j]$ (but need not be independent) and Assumption 1 holds.*

1. *If the products are symmetric – $A_1 = A_2 = \cdots = A_N = A$ – then unit fees lead to higher* total *payoffs than any other possible compensation scheme, but give lower expected payoffs to* buyers *than percentage fees.*

2. *If the products are asymmetric, then unit fees are no longer optimal, and either unit fees or percentage fees can potentially yield higher expected surplus.*

Result 3. *Assume sellers make price offers and Assumption 1 holds. As Figure 4 illustrates, when $N = 2$ and valuations are independent, unit fees give higher total surplus when the two products are nearly symmetric ($A_2 \approx A_1$), while percentage fees give higher total surplus when the asymmetry is significant.*

Proof of Theorem 3. Under Assumption 1, the seller disregards the selection in terms of the buyer he matches with, and names a price to maximize his payoff if he were facing a randomly-chosen buyer, which is $(p - c)\Pr(v_{i,j} > p) = (p - c)\frac{A_j - p}{A_j}$. This is maximized at $p = \frac{A_j + c}{2}$. This means that the buyer paired with seller j will trade with him if and only if $v_{i,j} \geq \frac{A_j + c_j}{2}$, or equivalently, $c_j \leq 2v_{i,j} - A_j$. Taking $v_{i,j}$ as fixed and c_j as still unknown, this means that when $v_{i,j} \leq \frac{A_j}{2}$, trade never occurs, and so $T(v_{i,j}, j) = R(v_{i,j}, j) = TS(v_{i,j}, j) = 0$ when $v_{i,j} \leq \frac{A_j}{2}$.

On the other hand, when $v_{i,j} > \frac{A_j}{2}$, trade occurs with probability $\Pr(c_j \leq 2v_{i,j} - A_j) = \frac{2v_{i,j} - A_j}{A_j} = T(v_{i,j}, j)$. Since trade occurs when $c_j \leq 2v_{i,j} - A_j$ and the seller demands price $\frac{A_j + c_j}{2}$, expected revenue is

$$
\begin{aligned}
R(v_{i,j}, j) &= \int_0^{2v_{i,j} - A_j} \frac{A_j + c}{2} \frac{1}{A_j} dc &&= \frac{1}{2A_j}\left[A_j(2v_{i,j} - A_j) + \frac{1}{2}(2v_{i,j} - A_j)^2\right] \\
&= \frac{2v_{i,j} - A_j}{2A_j}\left[A_j + \frac{1}{2}(2v_{i,j} - A_j)\right] &&= \frac{(2v_{i,j} - A_j)(2v_{i,j} + A_j)}{4A_j} \\
&= \frac{4v_{i,j}^2 - A_j^2}{4A_j}
\end{aligned}
$$

Total surplus generated by the pairing is

$$TS(v_{i,j}, j) = \int_0^{2v_{i,j}-A_j} (v_{i,j} - c)\frac{1}{A_j}dc = \frac{1}{A_j}\left[v_{i,j}(2v_{i,j} - A_j) - \frac{1}{2}(2v_{i,j} - A_j)^2\right]$$

$$= \frac{2v_{i,j} - A_j}{A_j}\left[v_{i,j} - \frac{1}{2}(2v_{i,j} - A_j)\right] = \frac{2v_{i,j} - A_j}{2}$$

Thus, in the symmetric case ($A_1 = A_2 = \cdots = A_N = A$), $T(v_{i,j}, j) = \max\{0, \frac{2v_{i,j}-A}{A}\}$ and $TS(v_{i,j}, j) = \max\{0, \frac{2v_{i,j}-A}{2}\}$, and so the matching σ that solves $\max_\sigma \sum_j T(v_{\sigma(j),j}, j)$ also solves $\max_\sigma \sum_j TS(v_{\sigma(j),j}, j)$ – the matching chosen under unit fees is the one that maximizes total surplus.

Given $v_{i,j}$, the buyer's expected payoff (for $v_{i,j} > \frac{A_j}{2}$) is

$$B(v_{i,j}, j) = \int_0^{2v_{i,j}-A_j} \left(v_{i,j} - \frac{A_j + c}{2}\right)\frac{1}{A_j}dc = v_{i,j}\frac{2v_{i,j} - A_j}{A_j} - \frac{4v_{i,j}^2 - A_j^2}{4A_j}$$

$$= \frac{4v_{i,j}^2 - 4A_j v_{i,j} + A_j^2}{4A_j} = \frac{(2v_{i,j} - A_j)^2}{4A_j}$$

Consider again the symmetric case ($A_1 = A_2 = \cdots = A_N = A$), and let $z_{i,j} = \max\{0, 2v_{i,j} - A\}$, so that

$$T(v_{i,j}, j) = \frac{z_{i,j}}{A}$$

$$R(v_{i,j}, j) = \frac{z_{i,j}(z_{i,j} + 2A)}{4A}$$

$$B(v_{i,j}, j) = \frac{z_{i,j}^2}{4A}$$

To show that percentage fees give buyers higher expected payoff than unit fees, we'll show that for any realization of buyer values where the two rules would lead the broker to select different matches, the match chosen under percentage fees gives higher expected buyer surplus.

Specifically, suppose that σ_u would be chosen under unit fees, and σ_p under percentage fees.

Then by revealed preference,

$$\sum_{j=1}^{N} T(v_{\sigma_u(j),j}, j) \;\; \geq \;\; \sum_{j=1}^{N} T(v_{\sigma_p(j),j}, j) \;\; \longrightarrow \;\; \frac{1}{A}\sum_{j=1}^{N} z_{\sigma_u(j),j} \;\; \geq \;\; \frac{1}{A}\sum_{j=1}^{N} z_{\sigma_p(j),j}$$

and similarly

$$\begin{array}{ccc} \sum_{j=1}^{N} R(v_{\sigma_u(j),j}, j) & \leq & \sum_{j=1}^{N} R(v_{\sigma_p(j),j}, j) \\ & \downarrow & \\ \frac{1}{4A}\sum_{j=1}^{N} z_{\sigma_u(j),j}(z_{\sigma_u(j),j} + 2A) & \leq & \frac{1}{4A}\sum_{j=1}^{N} z_{\sigma_p(j),j}(z_{\sigma_p(j),j} + 2A) \end{array}$$

Subtracting $\frac{A}{2}$ times the first inequality from the second gives

$$\frac{1}{4A}\sum_{j=1}^{N} z^2_{\sigma_u(j),j} \;\; \leq \;\; \frac{1}{4A}\sum_{j=1}^{N} z^2_{\sigma_p(j),j} \;\; \longrightarrow \;\; \sum_{j=1}^{N} B(v_{\sigma_u(j),j}, j) \;\; \leq \;\; \sum_{j=1}^{N} B(v_{\sigma_p(j),j}, j)$$

or the combined expected surplus of all the buyers is higher in the match chosen under percentage fees.

That proves part (i). For part (ii), note that under asymmetry, neither unit nor percentage fees always lead to the surplus-maximizing match, since

$$T(v_{i,j}, j) \;\; = \;\; \max\left\{0, \frac{2v_{i,j} - A_j}{A_j}\right\},$$

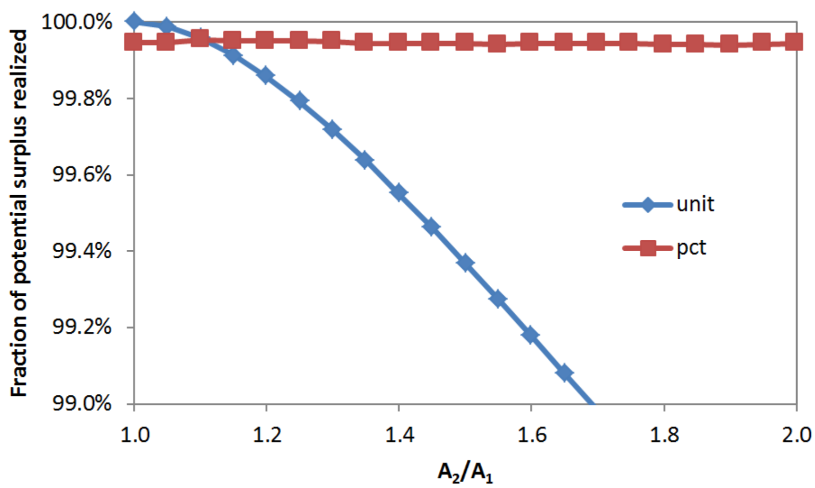
$$R(v_{i,j}, j) \;\; = \;\; \max\left\{0, \frac{4v_{i,j}^2 - A_j^2}{4A_j}\right\}, \text{ and}$$

$$TS(v_{i,j}, j) \;\; = \;\; \max\left\{0, \frac{2v_{i,j} - A_j}{2}\right\}$$

no two of which coincide for all combinations of $\{v_{i,j}\}$ and $\{A_j\}$; the simulated results below establish that either rule can give higher expected surplus. □

To understand the effect of asymmetry on the relative performance of unit versus percentage fees, we simulated valuations for $N = 2$, $\{v_{i,j}\}$ independent, $A_1 = 1$, and different values of $A_2 > 1$, calculating (for each realized set of valuations). We then calculated the surplus generated by the match chosen under both unit and percentage fees. Figure 4 shows the results: percentage fees begin to outperform unit fees when $A_2 \approx 1.1A_1$, and do better and better relatively as the asymmetry increases. When $A_2 = 2A_1$, unit fees yield 1.5% lower surplus than percentage fees; when $A_2 = 5A_1$, the difference is 5%.

Figure 4: Fraction of potential surplus captured under each type of fee, with $N = 2$ and independent valuations



That percentage fees work better under highly asymmetric products is intuitive. When the broker is choosing which buyer to match to which seller, percentage fees encourage him to give more weight to buyers' relative valuations for the "bigger" product, as it will lead to a larger expected commission – but the bigger product also generates more surplus when it trades. Unit fees lead the broker to put equal weight on each product's likelihood of trading – a greater and greater distortion as asymmetry increases. What was surprising to us is how little asymmetry is required for percentage fees to outperform unit fees – in the case we simulated, when one product is just 10% more valuable in expectation than the other, the two perform equally well, and when the asymmetry is bigger than that, percentage fees are preferable. This highlights how close the two are in performance in the symmetric case.

As for the differences between unit and percentage fees in the asymmetric case, we expect these differences to be even larger, not smaller, for larger N, for the following reason. With $N = 2$, even with $A_2 = 5A_1$, the two types of fees lead to the same match about 90% of the time; with more buyers and more sellers, and therefore more potential matches, we expect them to diverge more often. Thus, the results shown in Figure 4, we think, likely understate the degree to which percentage fees are preferable under asymmetry. (We did similar simulations for $N = 3$, and found the results to be almost identical to $N = 2$, but with a slightly larger gap in performance between percentage and unit fees, particularly as the degree of asymmetry got large.)

A.5 Extension: non-uniform c

Returning to the Nash bargaining model, we can extend Theorem 1 to the case where instead of being uniformly distribution, each seller's costs have the distribution $F_{c_j}(x) = (x/A_j)^\alpha$ over their support $[0, A_j]$, where $\alpha > 0$ is a parameter common to all sellers. In that case, trade still occurs whenever $c < v_{i,j}$, and at the same price as before, so now

$$\begin{aligned} R(v_{i,j}, j) &= \int_0^{v_{i,j}} (\phi c + (1-\phi)v_{i,j}) \frac{\alpha c^{\alpha-1}}{A_j^\alpha} dc = \frac{\alpha}{A_j^\alpha} \int_0^{v_{i,j}} \left(\phi c^\alpha + (1-\phi) v_{i,j} c^{\alpha-1}\right) dc \\ &= \frac{\alpha}{A_j^\alpha} \left(\phi \frac{v_{i,j}^{\alpha+1}}{\alpha+1} + (1-\phi) v_{i,j} \frac{v_{i,j}^\alpha}{\alpha}\right) = \left(\phi \frac{\alpha}{\alpha+1} + (1-\phi)\right) \frac{v_{i,j}^{\alpha+1}}{A_j^\alpha} \end{aligned}$$

and

$$\begin{aligned} TS(v_{i,j}, j) &= \int_0^{v_{i,j}} (v_{i,j} - c) \frac{\alpha c^{\alpha-1}}{A_j^\alpha} dc = \frac{\alpha}{A_j^\alpha} \int_0^{v_{i,j}} \left(v_{i,j} c^{\alpha-1} - c^\alpha\right) dc \\ &= \frac{\alpha}{A_j^\alpha} \left(v_{i,j} \frac{v_{i,j}^\alpha}{\alpha} - \frac{v_{i,j}^{\alpha+1}}{\alpha+1}\right) = \left(1 - \frac{\alpha}{\alpha+1}\right) \frac{v_{i,j}^{\alpha+1}}{A_j^\alpha} \end{aligned}$$

This time, both expected revenue and total surplus (as well as both buyer and seller surplus) are proportional to $v_{i,j}^{\alpha+1}/A_j^\alpha$ for each buyer-seller pair, so the match maximizing percentage fees also maximizes expected surplus for both sides. □

Appendix B: Tables

Table 1: Brokerage Regulations - Descriptive Statistics									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
variable	# obser vations	# towns	year mean (st. dev.)	year min max	population mean (st. dev.)	population min max	river port share	sea port share	mean # trade routes
single rules									
brokerage privilege	820	48	1462 (117)	1252 1699	35795 (27692)	1000 137220	0.46	0.41	5.38
private business constraint	480	34	1457 (119)	1252 1699	37726 (29331)	1000 125000	0.34	0.83	4.98
fixed fees	695	50	1471 (117)	1252 1699	31628 (27349)	1200 122600	0.37	0.49	4.93
unit fees	437	41	1462 (115)	1252 1692	33768 (29614)	1200 107150	0.35	0.52	4.78
value fees	235	35	1489 (132)	1252 1699	36085 (26500)	4300 122600	0.31	0.55	5.18
forced brokerage	81	16	1422 (68)	1282 1639	18505 (14914)	3000 63150	0.41	0.21	3.38
combination of rules									
matching	353	28	1459 (126)	1252 1699	51304 (30578)	4210 107150	0.31	0.58	5.15
matching with unit fees	231	22	1450 (128)	1252 1692	47297 (32348)	4595 107150	0.22	0.69	4.64
matching with value fees	116	20	1495 (143)	1252 1692	45130 (28581)	4820 107150	0.24	0.60	5.52
matching without private business constraint	125	22	1521 (102)	1339 1652	23957 (19887)	1200 71520	0.36	0.58	4.98
matching without fixed fees	30	15	1473 (92)	1335 1699	25616 (21818)	1000 90150	0.66	0.13	6.6
forced matching	44	6	1416 (60)	1282 1581	20232 (13018)	10000 50800	0.32	0	2.14
all observations	1609	70	1472 (108)	1241 1699	34174 (26845)	1000 137220	0.50	0.39	5.55

Notes: Columns (1) and (2) report the number of observations and towns for each brokerge rule or set of rules. Columns (3)-(6) show the mean, minimum, and maximum of the year and population of the city for the observations of each regulation. Columns (7)-(9) show the fraction of observations of each where the city has a river port, a sea port, and the average number of trade routes. Standard deviations are in brakets.

Table 2: Brokerage Regulations - Descriptive Statistics of Policy Statements

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Variable	# obs	# towns	promote facilitate trade	equal treatement	for the citi-zens	for the town	create order reduce damage
single rules							
only brokers	820	48	0.18	0.31	0.16	0.20	0.15
private business constraint	480	34	0.26	0.33	0.25	0.29	0.18
fixed fees	695	50	0.23	0.33	0.18	0.24	0.17
unit fees	437	41	0.30	0.27	0.20	0.30	0.17
value fees	235	35	0.18	0.34	0.26	0.22	0.22
forced brokerage	81	16	0.03	0.05	0.06	0.06	0
combination of rules							
Matching	353	28	0.34	0.39	0.31	0.37	0.22
matching with unit fees	231	22	0.45	0.35	0.32	0.47	0.22
matching with value fees	116	20	0.27	0.45	0.43	0.30	0.33
matching without private business constraint	125	22	0.18	0.58	0.09	0.22	0.22
matching without fixed fees	30	15	0	0.40	0.03	0.13	0.11
forced matching	44	6	0.05	0.02	0.05	0.07	0
all observations	1609	70	0.10	0.17	0.09	0.11	0.08

Notes: Columns (1) and (2) report the number of observations and towns for each brokerage rule or set of rules. (3)- (7) summarize the fraction of the specific regulations containting each of the identified policy statements.

Table 3: Implementation of Brokerage - Descriptive Statistics

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
	#obs.	#towns	# obs. with brokerage	mean population	mean pop. with brok.	pop. min max	pop min, max with brok.	year mean	mean year with brok.	year: min, max	year: min, max with brok.	mean trade routes	mean trade routes with brok.
bishop city	287	40	0.09	11794 (14644)	18537 (15248)	1000 100000	5000 62500	1447 (145)	1469 (125)	1200 1650	1200 1650	4.01 (1.88)	5.22 (1.25)
free imperial city	346	38	0.25	11287 (9732)	18211 (12664)	1000 55000	3000 55000	1440 (137)	1476 (119)	1200 1650	1200 1650	4.42 (2.14)	5.82 (2.25)
territorial city	1190	149	0.09	7384 (8128)	15662 (16600)	1000 127000	2500 127000	1457 (138)	1453 (119)	1200 1650	1200 1650	2.59 (2.02)	3.53 (2.19)
hanseatic city	332	41	0.12	9761 (9284)	22936 (15227)	1000 55000	3000 55000	1448 (138)	1450 (105)	1200 1650	1200 1650	4.03 (1.84)	6.15 (2.15)
University town	123	27	0.29	19630 (22388)	23944 (23716)	1000 127000	5000 127000	1531 (105)	1524 (96)	1200 1650	1350 1650	4.98 (2.20)	6.31 (2.08)
river port	697	96	0.13	10031 (11643)	16894 (14132)	1000 100000	3000 62500	1442 (141)	1459 (115)	1200 1650	1200 1650	4.97 (1.90)	5.90 (1.98)
sea port	251	32	0.26	11305 (13291)	20935 (18700)	1000 127000	3000 127000	1448 (138)	1484 (120)	1200 1650	1250 1650	2.69 (1.77)	3.65 (1.73)
total obs.	1823	227	0.12	8819 (9930)	17042 (14956)	1000 127000	2500 127000	1452 (139)	1464 (119)	1200 1650	1200 1650	3.16 (2.17)	4.66 (2.38)

Notes: Columns (1) and (2) report the number of observations and towns for the whole sample. Column (3) summarizes the share of observations with brokerage for each political and trade geographic charcterization of the sample. Columns (4)-(13) show the mean, minimum, and maximum for the year, population size, and number of trade routes passing through a city for all observations and for observations with brokerage regulations. Standard deviations can be found in brackets.

Table 3a: Implementation of Brokerage – Statistical Significance Tests

	(1)	(2)		
	chi2(1)	Paired t-test		
variables	p-value	(a) difference= mean regulation with brokerage – mean other obs.	(b) t-value	(c) p-value
bishop city	2.02 0.16			
free imperial city	71.40 0.00			
territorial city	34.48 0.00			
hanseatic city	0.08 0.78			
university city	37.93 0.00			
river port	2.70 0.10			
sea port	57.27 0.00			
year		-13.79	-1.37	0.09
population		-11283	-15.36	0.00
Trade routes		-1.79	-12.60	0.00

Notes: Table 3a investigates the statistical relationship between the implementation of brokerage and political, trade-geographic, demographic, and time variables. Column (1) gives the chi2 statistics and p-values for the relationship between the categorical variables and the implementation of brokerage rules. Column (2) shows the relationship between brokerage and continuous variables. (2a) shows the difference between the mean of a variable with brokerage minus the mean without brokerage, (2b) the related t-values and (2c) the p-values.

Table 4: (Matching With) Unit or Value Fees for Different Product Genres: Statistical Significance Tests								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
variables	#obs.	#towns	# obs. unit or value fees	share unit vs. value fees	Fisher's Exact test p-value	# obs. matching design with unit or value fees	share matching unit vs. value fees	Fisher's Exact test p-value
finance	103	24	42	0.07	0.00	18	0.11	0.00
property	47	16	24	0.08	0.00	12	0.00	0.00
horses	83	23	30	0.07	0.00	19	0.00	0.00
wine beer	124	33	56	0.95	0.00	32	0.97	0.00
grain	78	26	38	0.79	0.02	22	0.86	0.01
fish	89	22	33	0.94	0.00	15	0.93	0.01
cattle meat	50	18	19	0.89	0.01	8	0.88	0.15
construction material	78	21	50	0.82	0.00	22	1.00	0.00
metal	61	20	37	0.76	0.06	19	0.74	0.24
raw textile	104	28	56	0.43	0.01	31	0.39	0.02
furs skin leather	81	24	43	0.65	0.63	23	0.57	0.83
cloth	108	32	45	0.33	0.00	44	0.13	0.00
spices similar	77	27	52	0.67	0.37	24	0.67	0.52
total	1609	70	595	0.61		304	0.60	

Notes: Columns (1) and (2) report the number of observations and towns for each product genre. Column (3) gives the number of observations where either "unit fees" or "value fees" can be assigned. Column (4) gives the fraction of these which are unit fees. (In the rare case both types of fees are identified in one observation, this is considered to be unit fees.) Column (5) reports the related p-value of a Fisher 's Exact test analyzing the statistical relationship between the product genre and the binary variable of the fee choice. Column (6) gives the number of observations for which either the "matching with unit fees" or "matching with value fees" combination of regulations is observed; (7) gives the fraction of these which are unit fees, and (8) the related p-values for Fisher's Exact test.

Table 4a: (Matching With) Unit or Value Fees for Political and Trade-Geographic Binary Variables: Statistical Significance Tests

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
variables	#obs.	#towns	# obs. unit or value fees	share unit vs. value fees	chi2 p-value	# obs. matching design with unit or value fees	share matching unit vs. value fees	chi2(1) p-value
bishop	583	17	238	0.67	7.50 0.01	167	0.69	12.48 0.00
frs	549	26	219	0.54	6.36 0.01	105	0.44	17.22 0.00
territorial	229	31	97	0.70	4.47 0.04	31	0.68	0.89 0.35
hansa	431	14	163	0.52	6.56 0.01	96	0.50	5.69 0.02
uni	307	12	55	0.58	0.14 0.71	29	0.59	0.02 0.89
river port	645	35	208	0.64	2.06 0.15	78	0.62	0.12 0.73
sea port	604	16	303	0.57	3.00 0.08	190	0.62	0.62 0.43
total	1609	70	595	0.61		304	0.60	

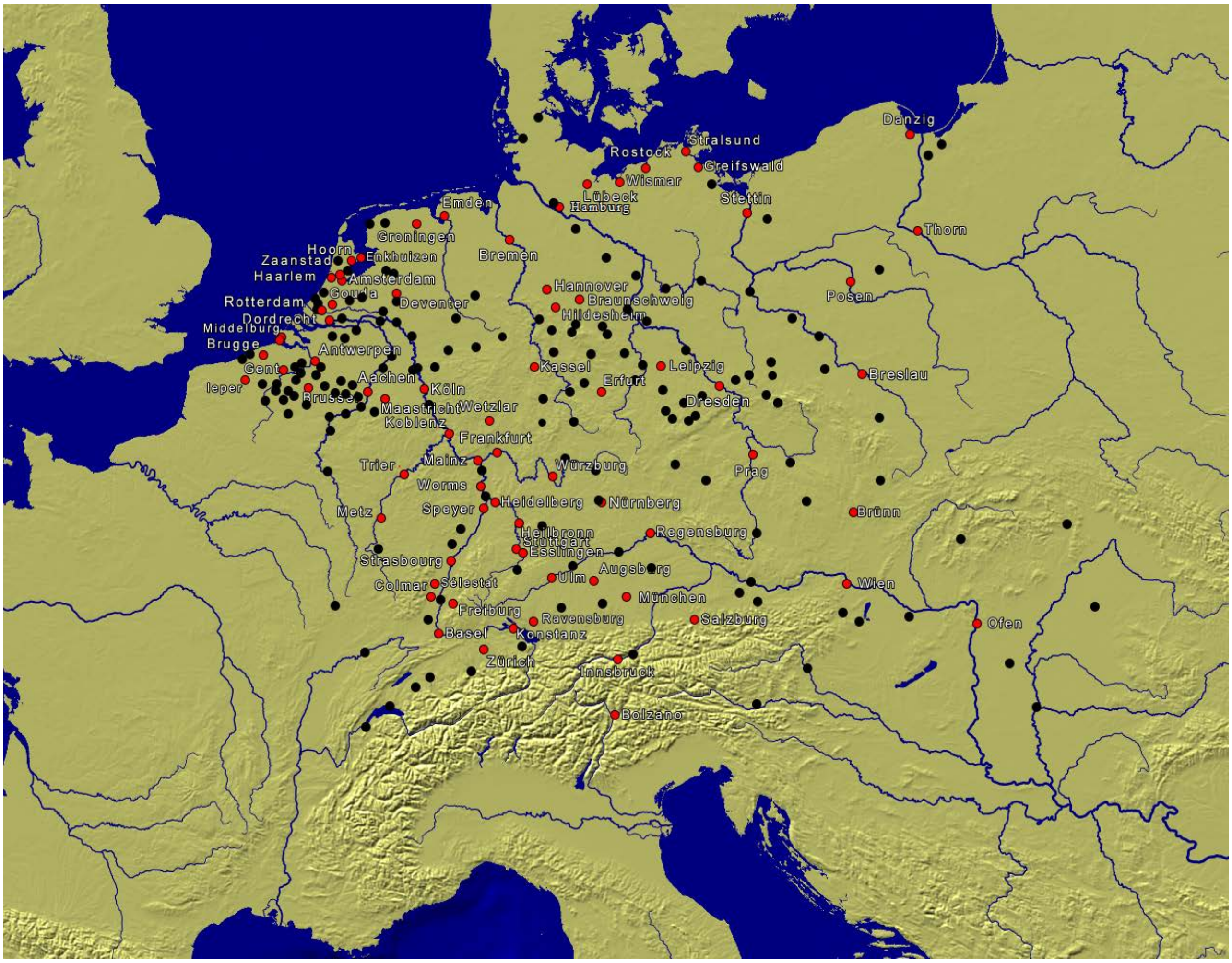
Notes: Columns (1) and (2) report the number of observations and towns for each political or trade-geographic variable. Column (3) reports the number of observations for which either unit fees or value fees are observed; column (4) gives the fraction of these which are unit fees, and column (5) the related chi2-statistics and p-values of the relationship between fee type and political or trade-geographic variable. Column (6) gives the number of observations of either the "matching with unit fees" or "matching with value fees" combinations of rules, (7) the fraction of these which were unit fees, and (8) the related Chi2-statistics and p-values.

Table 4b: Statistical Significance Tests for Other Continous Variables									
	(1)			(2)			(3)		
	period paired t-test			population paired t-test			# trade routes		
design	(a) difference= mean regulation – mean other obs.	(b) t-value	(c) p-value	(a) difference= mean regulation – mean other obs.	(b) t-value	(c) p-value	(a) difference= mean regulation -mean other obs.	(b) t-value	(c) p-value
unit vs percentage fees	32.77	3.03	0.00	5409	1.90	0.03	0.40	1.83	0.04
matching with unit vs value fees	50.07	3.34	0.00	494	0.13	0.44	0.99	3.74	0.00

Notes: Table 4b investigates if different fee structures, and matching designs with different fee structures, relate in a statistically significant way to time, population, and the number of trade routes in and out of a city. Column (1) depicts paired t-tests comparing differences in the mean of year for regulations with unit fees versus regulations with percentage fees, and for the matching design with unit fees versus matching with value fees. Column (1a) reports differences between the mean years, (1b) the related t-values, and (1c) the related p-values of a paired t-test. Column (2) reports the results for paired t-tests for differences in population size, and column (3) the results for differences in the mean number of trade routes passing through a city.

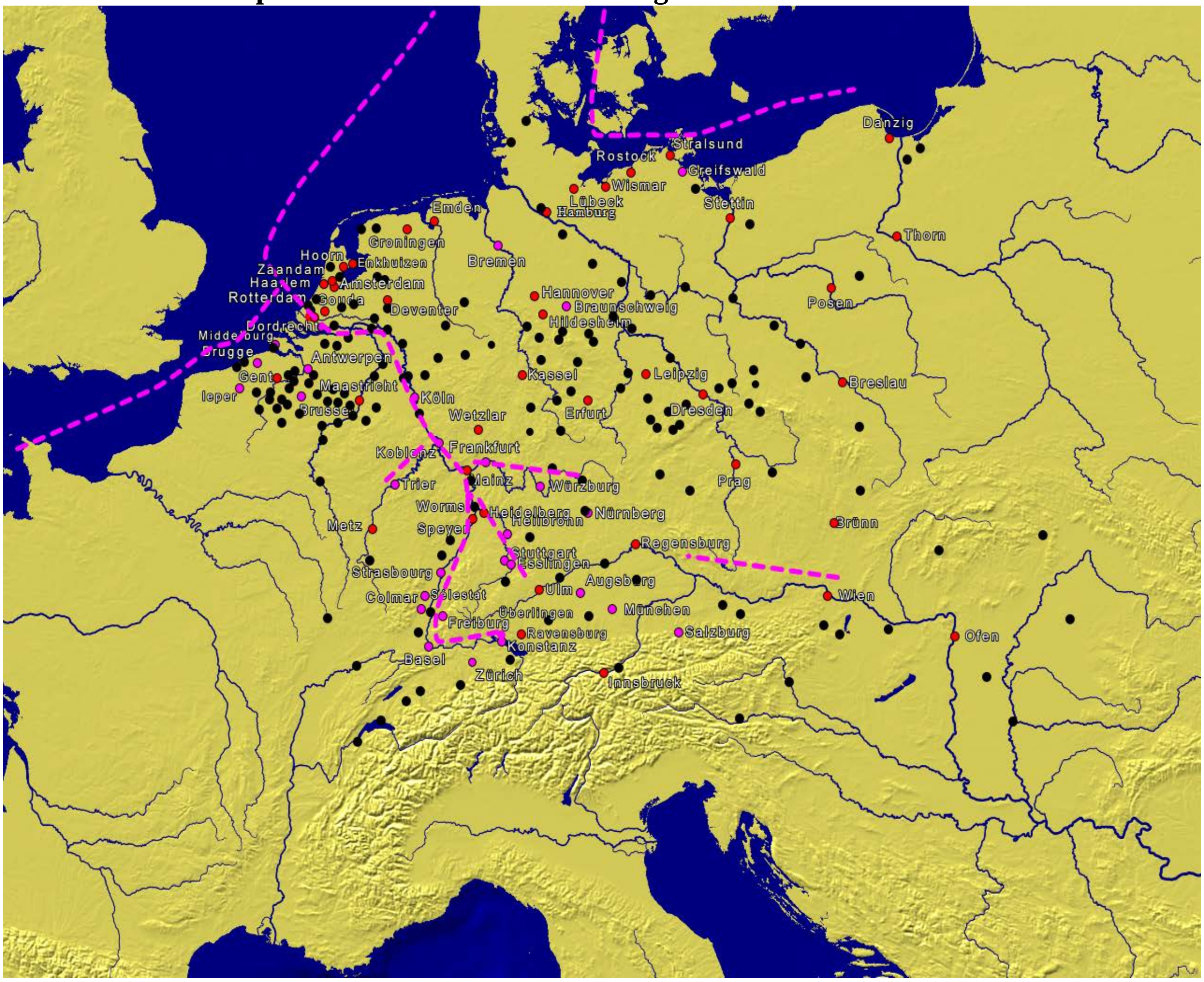
Appendix C: Maps

Map 1: Sample of Cities With and Without Brokerage



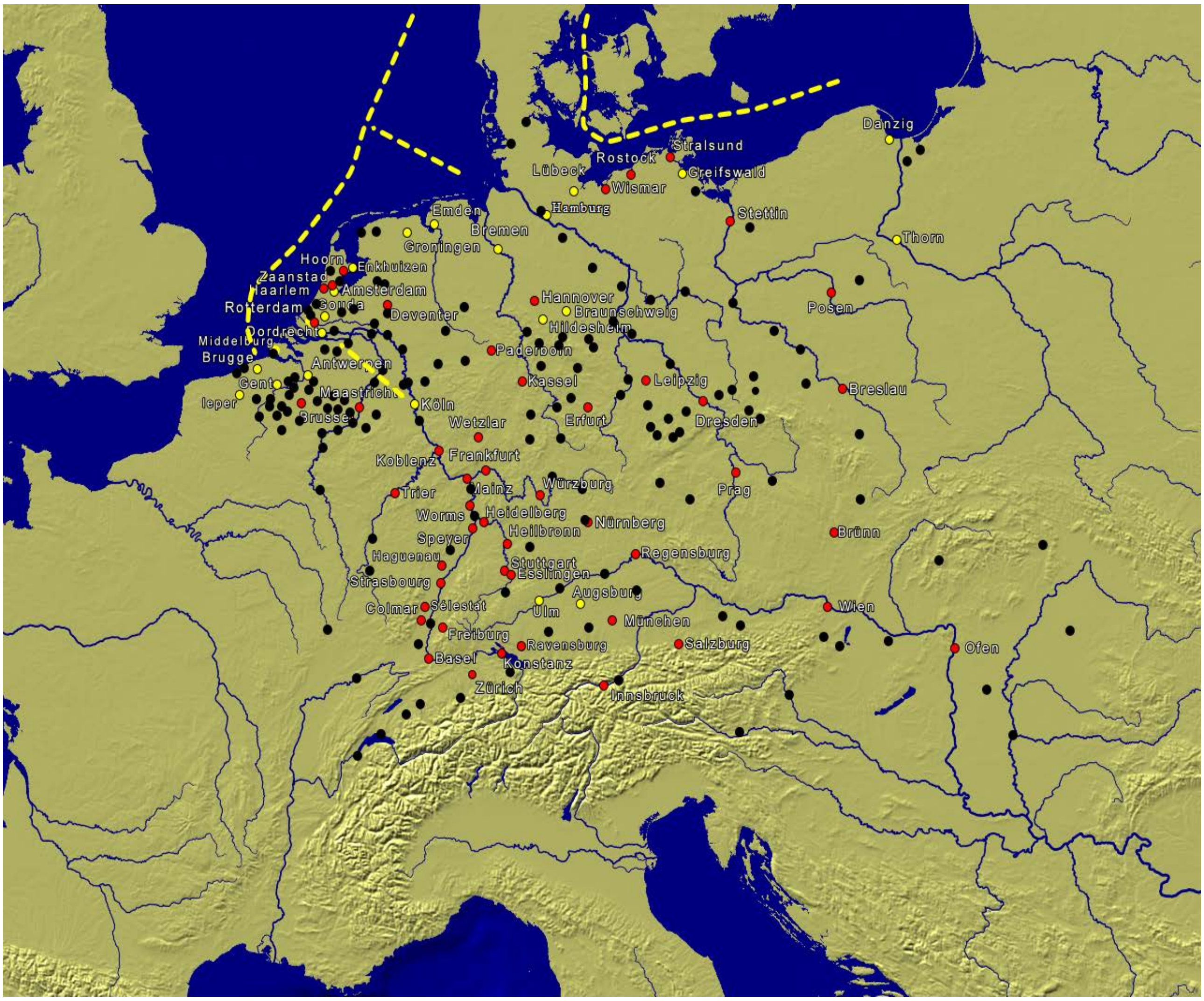
Notes: The dots depict all towns which have been investigated and had following Bairoch (1988) at least once during the investigation period (1200-1700) 5000 inhabitants. The towns marked in red colour and provided with names indicate the existence of brokerage. Other towns (without brokerage) are marked in black.

Map 2: Towns With Wine Brokerage and Wine Trade Routes



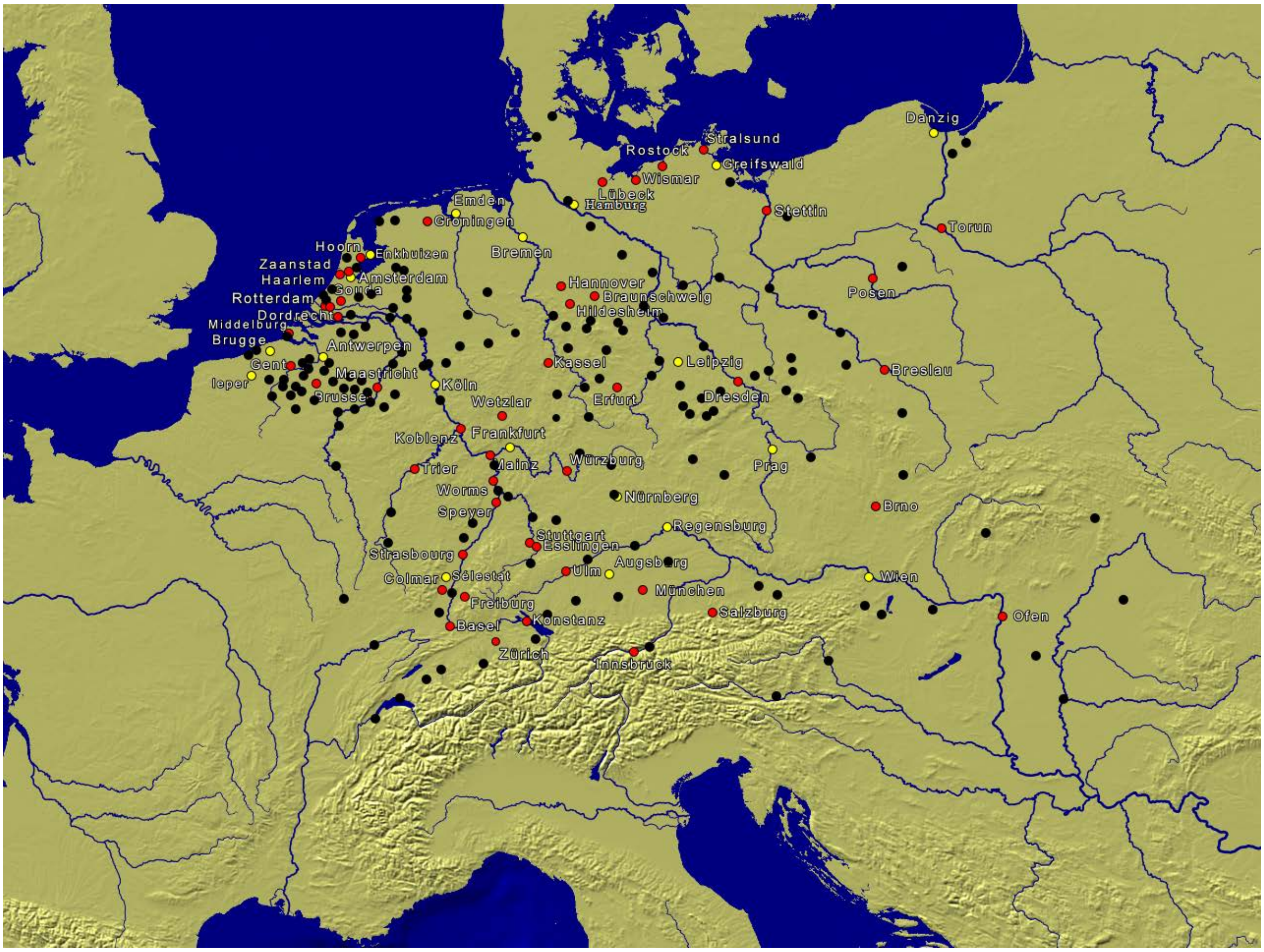
Notes: Cities with wine brokerage are marked with purple dots and provided with names. Purple dashed lines indicate main wine trade routes. Other cities with brokerage (following map 1) are marked with red color dots and also provided with names. The remaining towns are marked with black dots only.

Map 3: Towns With Grain Brokerage and Grain Trade Routes



Notes: Cities with grain brokerage are marked with yellow dots and provided with names. Yellow dashed lines indicate main grain trade routes. Other cities with brokerage (following map1) are marked with red color dots and also provided with names. The remaining towns are marked with black dots only.

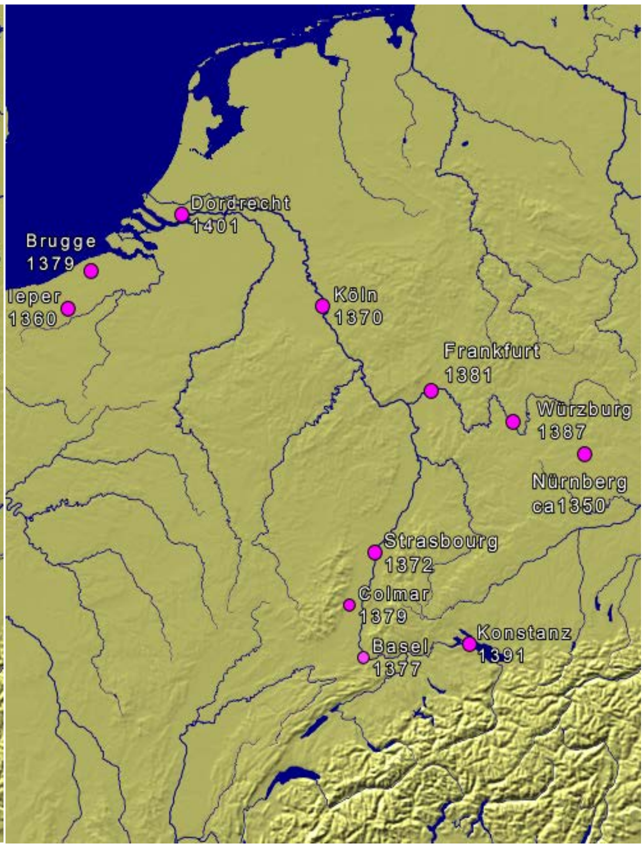
Map 4: Towns With Finance Brokerage



Notes: Cities with finance brokerage are marked with yellow dots and provided with names. Other cities with brokerage (following map 1) are marked with red color dots and also provided with names. The remaining towns are marked with black dots only.

Map 5: Brokerage Matching Design Along the Rhine/Maine/Meuse/Scheldt Area

a) matching mechanisms



b) matching mechanisms for wine ca. 1350-1400