Modelling Maritime Trade Systems: Agent-Based Simulation and Medieval History

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Modelling Maritime Trade Systems: Agent-Based Simulation and Medieval History

Ulf Christian Ewert & Marco Sunder *

Abstract: »*Mittelalterlicher Seehandel im Modell - eine Anwendung agentenbasierter Simulation in der Mediävistik.*« Maritime trade grew enormously in Europe after c. 1100 AD, thereby contributing much to the European economic take-off commonly considered as the "Commercial Revolution of the Middle Ages." In this article, determinants of both the formation of the Hanse's network-based system of trade in Northern Europe and its later dissolution are analysed using a multi-agent model. Findings are connected to the discussion in institutional economics and economic history concerning the importance of institutional developments in long-distance trade for economic growth in medieval Europe, the efficiency of self-enforcing institutions, and the divergence of institutional arrangements in medieval maritime trade. Finally, both potentials and limitations of agent-based models for historical research are discussed.

Keywords: Commercial revolution, medieval maritime trade, multi-agent models, network organisation, Hanse.

1. The Rise (and Fall) of Medieval Trading Systems

1.1 The Commercial Revolution and Institutional Arrangements in Medieval Trade

After c. 1100 AD, Europe saw an unprecedented economic take-off with huge demographic and social dynamics unfolding all across the continent. A constant increase in population, a huge expansion of arable land, the foundation of hundreds of towns and a sustained economic growth resulting from all this formed the background of what certainly has to be considered not only an economic take-off, but also a significant societal change. A concomitant of this process was the re-establishment of long-distance trade, an issue that, following the seminal analysis of Robert S. Lopez, is commonly referred to as the "Commercial Revolution of the Middle Ages" (Lopez 1976 [1971]; Epstein

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2009). At first, such a general economic take-off can be observed in Western Europe and in the Mediterranean in the late eleventh and early twelfth centuries, but it eventually spread over most of the continent and reached also Northern Europe and the Baltic within the second half of the twelfth century.

An important element of this "Commercial Revolution" was the enormous growth of maritime trade in some European regions, which allowed for a further geographical specialisation of production and fostered European market integration – at least in part – through linking distant port towns. Coastal areas thus developed faster than inland regions – in the Mediterranean as well as in the Baltic. Compared with overland trade, maritime trade for long seems to have been a more important means to transfer commodities over long distances. At the periphery of Europe, in the Mediterranean, but also in the Baltic and in the North Sea, commercial exchange via the open sea was inevitable, of course. However, the introduction of the re-designed magnetic compass in the Mediterranean during the late thirteenth century triggered a further substantial rise in the rate of commercial exchange, because ships now were able to cross the open sea even during winter when traffic had rested before (Lane 1963). Furthermore, before mid-fifteenth century political insecurity, warfare and an underdeveloped and insufficient infrastructure of overland transportation made maritime trade more attractive even in regions of Europe were long-distance trade, to some extent at least, was already operated overland. Sea transportation often was simply faster than overland transportation, even though it always was risky and dangerous due to bad weather and piracy (Munro 2001). A good example for this is certainly the establishment of a regular galley service between Venice and Bruges in the late thirteenth century and its maintenance well into the fifteenth century.

The institutional economics literature concerning the economic history of Europe recurrently points to the fact that institutions had a formative impact on Europe's economic take-off during the Middle Ages (North 1981, 1990, 1991). Institutions can be designed in such a way that they are able to either enhance or to spoil personal and impersonal exchange, depending on whether the institutional design allows traders to reduce transaction costs in a significant manner, or instead increases these costs (North 1985). As over the course of time the majority of medieval merchants became more or less sedentary, which in turn made impersonal exchange more important, especially the invention and implementation of institutions capable of enforcing the merchants' property rights abroad is believed to have enhanced the huge expansion of commerce in medieval Europe (Milgrom, North and Weingast 1990; North 1991, 1993; Greif 1997, 2000, 2002b, 2006; Ogilvie and Carus 2014).

Nevertheless, paths of institutional development obviously were different across Europe. Regions in which large systems of long-distance trade developed during the high Middle Ages were the Mediterranean, Western Europe, and the Baltic. Whereas the Western European system around its core of the

Fairs of Champagne (Bautier 1953; Berlow 1971; Thomas 1977; Schönfelder 1988) was characterised by overland trade, the two other systems were essentially maritime in character. Interestingly enough, these systems of long-distance maritime trade differed substantially with respect to structure and performance. While a primarily law-based trade system emerged rather early in both Western Europe and the Mediterranean, providing merchants – who predominantly were of Italian origin – with formal institutions, a kinship-based network structure persisted in Northern Europe among the merchants of the Hanse, who basically relied on informal and self-enforcing institutions (Ewert and Selzer 2016). This observation points to a current debate on whether either the clever design of self-enforcing institutions – a hypothesis advocated by Avner Greif (Greif 1989, 1992, 1993, 2000) – or the establishment of law-based institutions – as Sheilagh C. Ogilvie and Jeremy Edwards argue (Ogilvie 2007; Edwards and Ogilvie 2011, 2012) – finally caused the rise of long-distance trade and the immense growth of medieval commerce.

1.2 Network Characteristics of Hanseatic Long-Distance Trade

Medieval Northern European trade was dominated by merchants from Lower Germany and the Baltic – the so-called Hansards. Based upon the privileges they had been granted in London, Novgorod, Bruges, and Bergen, they founded trading outlets (*Kontore*) in these important markets (von Brandt 1963; Dollinger 1964; Bracker 1989). The Hanse, like the entire merchant community was named, monopolised commercial exchange in the North Sea and the Baltic until the turn of the sixteenth century. While during the "Commercial Revolution" merchants elsewhere in Europe began to deploy sophisticated techniques, formal contractual schemes and complex organisation patterns to handle risk capital, operate cashless payments and transmit market information quickly via huge distances (Lopez 1976 [1971]; Epstein 2009), many of such techniques either were only poorly developed or even missing in Northern Europe. Even in the fifteenth and early sixteenth centuries, the Hansards, each of whom usually had only a small amount of capital at hand, traded still mainly with each other, and they did this on the basis of mostly informal, only implicitly defined contracts (Selzer and Ewert 2001; Ewert and Selzer 2007, 2010). These trading networks of different size and varying density (Selzer and Ewert 2001; Ewert and Selzer 2007, 2015) were medium-term or long-term cooperations of legally independent merchants, being primarily based on kinship and friendship (Sprandel 1984; Stark 1993). Information on network structure can be drawn only for the late medieval period from different types of sources – account books, letters, and wills (Ewert and Selzer 2015, 2016), for example. A merchant could have up to c. 40 trading partners in a period of about 30 years, and cooperation with a single partner could last up to 22 years.[1] Mutual relationships between Hansards and their social proximity to each other can also be grasped from their joint membership in town councils, merchant societies, and merchant associations (Dünnebeil 1996; Selzer 1996; Asmussen 2002; Burkhardt 2009), their nearby lodging in the Hanse towns (Hammel 1985; Igel 2005) and their mutual choice of one another as future executors of their wills (Meyer 2002, 2005, 2010).[2]

The core structure of networks typically consisted of mutual transactions between two partners at distant locations, each partner selling the other partner's goods. Such commercial cooperations neither needed formal contracting nor have they been exclusive, and a selling merchant was usually not paid by the sending merchant for taking the commercial risk entailed with the sale. This sort of reciprocal trade was by far the most important pattern of commercial exchange between Hansards (Mickwitz 1937, 1938; Sprandel 1984; Stark 1993; Cordes 1998, 2000).[3] Core partnerships – i.e. stable and persistent exchange relationships showing a high frequency of mutual exchange – are thought to coincide significantly with family ties (Koppe 1933; Cordes 1998). An instructive example of such a kinship network is the *Veckinchusen* family. From Bruges, where he lived at the beginning of the fifteenth century, *Hildebrand Veckinchusen* traded regularly – on the basis of reciprocal exchange – with his brothers, his cousins, his father-in-law, his nephews, and some of his friends in Lübeck, Danzig, Riga, Reval, and Dorpat (Irsigler 1985; Stark 1993; Cordes 1998; Greve 2002; Selzer 2010; Ewert and Selzer 2015, 2016). Together with his brother *Sivert* he also was member of a formal company through which he operated his trade with Cologne (Schweichel 2002).

Yet, the Hanse's network organisation of trade was more than just a simple overlap of family and business circles. The pattern that had evolved through the trading activities of the Hansards is quite typical for a network organisation (Selzer and Ewert 2001, 2005, 2010; Ewert and Selzer 2007, 2010, 2016). Such an organisation is defined as a loose cooperation of legally and economically independent entities. Through "networking" a "new" structure evolves which constitutes the framework for potential cooperations between the members of a network. In theory, such an inter-organisational network has no hierarchy.

1 This is derived from account books that are preserved for the merchants *Johann Pisz (Pyre)* from Danzig, *Vicko von Geldersen* from Hamburg, and *Hermann* and *Johann Wittenborg* from Lübeck. The account book of *Johann Pisz (Pyre)* covers a period of about 32 years.

2 Networks of Hansards involved in the trade with Bergen, for example, are documented in Burkhardt (2009, 2012).

3 There also existed the *sendeve*, a kind of commission business. In this well-defined contractual scheme the commission agent sold the goods he had received from another merchant by order and for account of the partner who had formally instructed the sale and had sent the goods to the commission agent, with profits and risk remaining with the sender (Cordes 1998, 1999).

Hence, cooperations between network members may be thought of as voluntary and flexible couplings (Powell 1990; Illinitch, D'Aveni and Levin 1996; Osborn and Hagedoorn 1997; Windeler 2001). In the Hanse case small-scale businesses of self-employed merchants with only little financial power each formed such networks by mutually cooperating in reciprocal trade. Commercial exchange was coordinated by culture, trust, and reputation.[4] Belonging to a broader family, sharing common values and speaking the same language facilitated exchange between Hansards considerably. Outside families cultural correspondence between network members was established and maintained by institutions and social events that allowed network members to socialise with each other. The "King Arthur's courts" (*Artushöfe*) in the Baltic (Selzer 1996) or the "Society of the circle" (*Zirkel-Gesellschaft*) of Lübeck (Dünnebeil 1996) are good examples of such institutions where merchants and political leaders of the local town met guests from other towns, celebrated festivities, and exchanged all kinds of commercial information. These institutions were also important for the enforcement of fairness within commercial networks, since they allowed information on the reputation of individual network members to be distributed across the entire network (Selzer 2003). Not to lose good reputation was the primary incentive of network members to act fairly, as cheating not only destroyed the relationship with the betrayed partner but also resulted in a loss of access to the whole network and thus undermined other possible partnerships in the future. While commercial information would have had to be transmitted quickly to control particular trade operations – which was almost impossible given the information technology of the time – for the transmission of information on reputation slower channels were sufficient to prevent fraud among merchants. The kinship- and friendship-based network provided its members with a certain degree of flexibility at only moderate costs of transaction, information, and organisation and it always offered opportunities to establish commercial contacts inside the broader community of Hansards (Ewert and Selzer 2015, 2016).

1.3 Focus and Structure of the Paper

Why did institutional arrangements of trade develop so differently? And what made arrangements to develop in either one or another way? The focus of this article is therefore laid upon determinants that potentially shaped specific patterns of medieval long-distance trade, in particular those of maritime trade.

In general, the aim is at modelling commercial exchange with an agent-based model that captures some of the relevant features of medieval maritime trade, such as the geographic spread of resources, distance-based transportation

[4] Such means of coordination are often assumed to compensate for a missing hierarchy (Powell 1990; Galaskiewicz 1996; Staber 2000).

costs, trade privileges, and information asymmetries. The model and its setup will be described in more detail in the subsequent Section 2 of this paper.

More specifically, simulation runs of this model are used to analyse tentatively emergence, formation, and later dissolution of the Hanse's network-based system of trade, by which Hanseatic merchants were capable of more or less monopolising trade in the Baltic and the North Sea until the late fifteenth century. One objective is to illustrate possible paths of the emergence of a network pattern in medieval long-distance trade that – as is the case of Hanseatic commerce – can only be traced in the surviving historical records of the fourteenth and fifteenth centuries, long time after the network had been formed. Findings and interpretation are presented in Section 3.

Based upon these findings, and taking Hanseatic commerce also as a case study, a tentative interpretation of why the institutional arrangement of maritime trade in the Mediterranean might have developed in a different way will then be given in the closing Section 4, along with some thoughts about the feasibility of modelling and simulation approaches to (medieval) history in general.

2. A Multi-Agent Model of Medieval Maritime Trade

2.1 Modelling Prerequisites and General Setup of the Model

First of all, a simulation model of medieval maritime trade is defined. Its design captures some of the features considered to be fundamental in medieval maritime trade – a geographic spread of resources, transportation costs increasing with distance, trade privileges, and information asymmetries. The model consists of a square world in which 64 towns arranged akin to the fields of a chessboard. Each town has an initial population of n = 1,000, and two goods can be produced in or around the town: foodstuffs (F) and manufactured goods (C).[5] Among the citizens of each town an equal distribution of wealth is assumed, and a town's welfare is defined as

$$W = \sqrt{F \cdot C}/n .$$

A limited amount of both goods is produced and consumed autonomously by the population in each town, irrespective of population size. This amount is set to 30 for both types of goods. Larger amounts may become available if there is a merchant in the town. While total population is fixed in the model, towns with higher welfare attract population from neighbouring towns. However, only a small fraction (c. 5 per cent) of the entire welfare-equalising migration

[5] A typical manufactured good in the Middle Ages that was traded across Europe were textiles and cloth. So, *C* here stands for cloth.

occurs within a period to ensure that larger towns may withstand even short periods of decreasing welfare. Migration takes place only at the end of each period of the simulation, after both production and trade of commodities have been completed (see Figure 1 below).

2.2 The Production of Goods and Trading Activities of Merchants

Merchants are the agents of the model. To keep things simple, by assumption no more than one merchant can settle in a particular town. Settlement requires the payment of a lump sum tax, which is subtracted from the merchant's wealth in each period. This tax is set to 500 units within the simulation. Merchants can increase their wealth by selling commodities to the local population and/or by engaging in long-distance trade with other merchant towns. Each merchant trades with one of the two goods, according to the specialisation of his home town. How much is produced in each period is a function of the local population size

$$X_i^{prod.} = S_i \cdot n^{\beta} \ ,$$

with $X_i \in \{F^{prod.}, C^{prod.}\}$. The dichotomous variable S_i takes on the value 1 in the case foodstuffs are produced (or manufactured goods) in a town with a specialisation in foodstuffs (or manufactured goods) and the value 0 otherwise. In all simulations β is set to 0.6, thereby assuming diminishing returns to town size. After production, the merchant may sell the town's produce locally and/or engage in long-distance trade with other merchants in distant towns. For the latter purpose, each merchant is in possession of one ship on which he can carry a limited amount of the good that is produced in his home town. This capacity limit is set to 30 units of one of the two goods in all simulations. Selling the produce locally means both selling it to the local population and to other merchants whose ships may have arrived in the local port. No trade is possible with towns that do not have a merchant.

A merchant's decision whether or not to send his ship away and what cargo should be loaded for the travel to the distant town and/or the way back depends on the profit he is expecting of a trading voyage. To calculate expected profits opportunity costs are considered in the sense that the produce could also be sold at home. Every second stint of a trading voyage has to have the home town as its destination, so by assumption merchants in the model return immediately home in the next period, and they are not capable of solving travelling salesman problems that are more complex than a simple round-trip. Profit expectations depend on the beliefs about prices in all merchant towns, including the merchant's home town. Each merchant has his own set of price beliefs for each of the towns. These beliefs depend both on his own experiences and on rumours he had heard in the past. While price signals from distant towns are received with noise, those from his home town or the town where his ship is currently located are received without noise once all transactions of a period have been settled. He also uses his price belief for his home town when deciding upon his trading strategy. This implies that his strategy does not account for the cargo of ships sailing towards his home town. Furthermore, both expected and actual net-returns of a trading voyage depend on distance-based travelling costs and a fee that merchants of distant towns charge from the ships entering their harbours. Having completed a round-trip, ship owners update their beliefs about the net-returns for the respective destination town by calculating the difference between actually realised returns and those originally expected. Such deviations from the original plan may arise, for example, from limitations of supply in the town of destination.

The price a merchant believes to realise in his home town is assumed to equal the price he charges other merchants when they purchase goods from him to load on their ship. The other party will always accept this price, without second thoughts. Ships that unload cargo sell their goods to the local population – as does the local merchant if he sells his own produce at home. In this type of transaction, the price is a function of the entire quantity supplied in period *t* by autonomous production, incoming ships, and the local merchant. To avoid abrupt jumps in price volatility, an autoregressive component is introduced, which gives

$$p_{X_{i,t}} = \alpha \cdot m/(2X_i) + (1-\alpha) \cdot p_{X_{i,t-1}} \ ,$$

where $X_i \in \{F, C\}$. The parameter m reflects the town's long-run budget, which depends on the size of the population. Parameters are set to $m = n$ and $\alpha = 0.5$ in all simulations.

2.3 Merchant Demography and Kinship Networks of Trade

Due to the lump sum tax or due to misconception about the net-returns from long-distance trade, a merchant's wealth may become negative. In such a case of "bankruptcy" he disappears from the scene, thereby providing an "empty" town for a new merchant. Ships arriving at a town whose merchant has just disappeared will return to their home town and sell their cargo there.

New merchants may come into being either by instantaneous creation or as an offshoot of an existing merchant. In both cases, the new merchant is equipped with an initial wealth of 1,000 units. Each period of the simulation in which there is at least one empty town with a specialisation in manufactured goods production sees the randomly chosen instantaneous creation of exactly one merchant in one of these empty towns. Such a merchant forms a new trade dynasty. His beliefs about the prices of goods in the various towns are vague – simply median prices plus some noise. Offshoots, in contrast, belong to the dynasty of their parent merchant, of whom they inherit their initial wealth (also 1,000 units) and also adopt their initial beliefs about prices of commodities. Offshoots occur in an empty town nearby the parent, irrespective of the town's specialisation. This sort of "birth" of new merchants forms the basis of trading networks in the model. Irrespective of wealth, a merchant disappears after his fifteeth period of existence. In this case, a nearby merchant of the same trade dynasty – if there is any – inherits the wealth.

Apart from the possibility to inherit wealth, further potential advantages of belonging to a kinship-based commercial network are assumed: price signals from towns of the same network are received with a lower noise component, no fees are levied from ships sailing to a town whose merchant belongs to the same dynasty as the ship owner, and ships from the same dynasty as the local merchant are granted preferential access to buying cargo for their trip back home.

All of the assumptions made are justified in a sense with historical evidence found for the period after 1300 AD regarding the trading practice of Hansards. Commercial assets were transferred to the next generation according to formal wills. Information on prices of commodities at different markets was shared among commercial partners at distant locations by sending each other letters. Information on other merchants' reputation was exhanged within merchant societies and merchant associations. Hanseatic merchants sent their sons for apprenticeship to their relatives living in other towns. And in all of the Hanse towns trade with non-Hansards was firmly restricted or even prohibited by law (Ewert and Selzer 2016).

2.4 Implementation of the Model

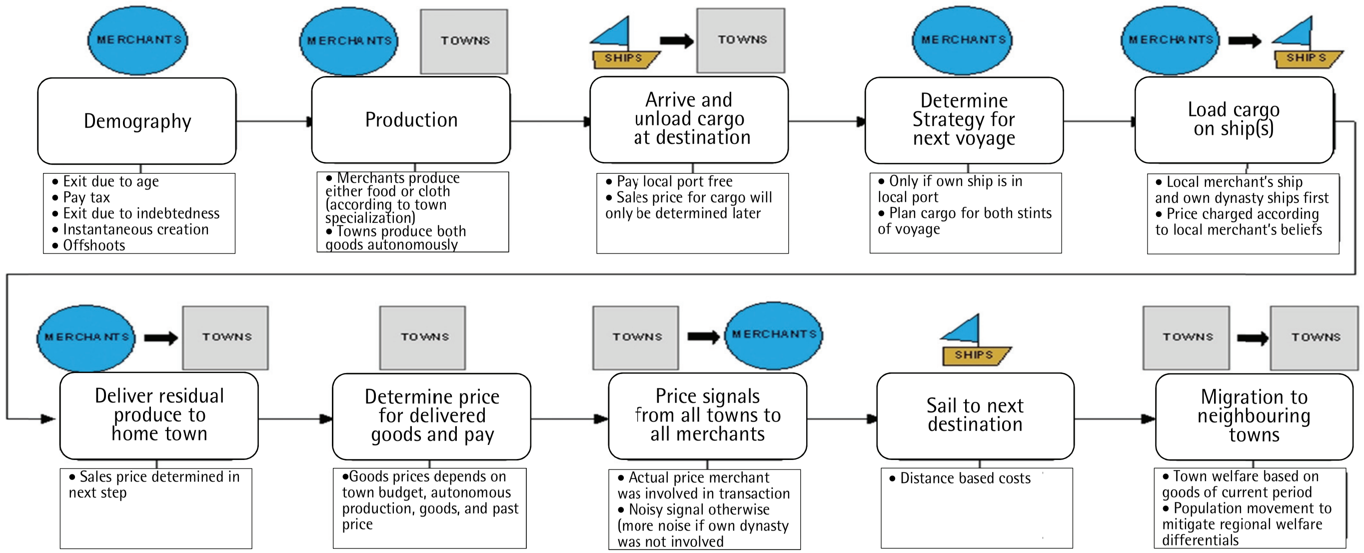
An agent-based simulation approach is chosen here mainly for two reasons: firstly, in commercial exchange by definition more than one agent is involved, and single merchants only had limited access to the commercial information on which they could base their decision-making. As a consequence, it is necessary to allow for individual decisions, so that in the end a complex and observable macro-structure emerges such as the pattern of exchange resulting from various individual commercial activities of agents (merchants) at the micro-level (Doran 1996; Epstein and Axtell 1996). Secondly, geographic differences in the disposal of resources and in economic specialisation are important factors for trade and for the emergence of a trading system. Thus, different agents (merchants) are needed to represent this kind of economic variety.

The multi-agent model defined above is implemented with NetLogo, version 4.1.3 (Wilensky 1999). The flow-chart depicted in Figure 1 covers the various steps necessary to be computed in order to complete one period of the model.

A round-trip (trading voyage) of a ship takes two periods in the model.[6]

[6] When a ship is sailing back home with cargo, this cargo will only be unloaded in the third period. However, it can already load new cargo in the third period, which thus marks the beginning of the next round-trip.

Figure1: Flow Chart of One Period of the *Simulation Model*



Given the typical medieval maritime trade pattern, two periods roughly correspond to a year, because sea merchants usually were able to complete a trading voyage to an overseas commercial destination within the same year. The analysis of the model always starts with a town grid of equal population size and with no merchants. Half of the towns are specialised in manufacturing goods, the other half in producing foodstuffs. One "replication" of the simulation consists of running 600 periods of the model, which shall provide enough time for a particular pattern of trade to emerge and to develop. Different scenarios are set up by varying parameter settings. For each scenario 250 replications of these histories are run to obtain an understanding of the "typical" course of events and their distribution. The outcomes of different scenarios can then be compared with each other.

3. A Case Study: the Hanse's Network Organisation of Trade

3.1 Formation and Persistence of the Hansards' Trading Networks

Even though the Hanse's network organisation of trade presumably was instrumental in bringing the "Commercial Revolution" to Northern Europe (Hammel-Kiesow 2000; Selzer 2010), its persistence until the end of the Middle Ages and beyond is nevertheless quite astonishing. Hansards delivered all sorts of goods to the consumers in the towns that had begun to flourish in the entire Baltic area (Selzer and Ewert 2001; Selzer 2010). They had crowded competitors out of long-distance trade in the North Sea and the Baltic, and in the process most of them became sedentary. During the late Middle Ages, Hanseatic merchants defended their major trade privileges successfully, and even though they had neither formed large firms nor adopted the – by that time – state-of-the-art trading techniques, they enjoyed a nearly perfect trade monopoly in the Baltic, at least until the late fifteenth century. How did this rather simple trading system evolve, which enabled Hansards to dominate Northern European trade so extensively? And why did it survive for such a long time? As only little information on specific merchants from the period before 1300 AD has survived, it is not clear how the closed kinship-based commercial networks – which are so typical for Hanseatic trade after 1300 AD – were built nor why they had been formed at all. In order to compensate for the scant data of the early period of Hanseatic trade, agent-based simulation appears to be a viable strategy to analyse these problems.

3.2 Simulation Results from a Baseline Scenario

The presentation of simulation results first covers a scenario which is referred to as the "baseline scenario." This scenario is calibrated in such a way as to reflect some conditions of Northern Europe in the eleventh to thirteenth centuries. The preset specialisation of towns follows an east-west pattern – manufactured goods specialisation is available in the western half of the map, foodstuffs in the east. Merchants, who trade in towns that do not belong to a merchant's own family network, would have to pay a very high fee (of 350 money units). This basically curtails all trade across dynasty boundaries. Furthermore, transportation costs are set to 40 money units per unit of distance, which seems high enough for geographic location of towns to be a relevant factor in the merchants' trading strategies.

The outcome of the simulation is measured in terms of a set of indicators that reflect the pattern of the trading system, economic development and welfare effects: The structure of the emerging trading system is measured in terms of the *network density*, defined as the ratio of all family ties to all ties possible, the *dominance of the largest network*, defined as the ratio of ties within the leading family network to the aggregate number of ties occurring in all other families,[7] the *persistence of leadership,* defined as the propensity of the largest network in period $t = 400$ to hold this position also in period $t = 600$, and the median period of the *first occurrence of a family network* consisting of at least five merchants, a proxy for the speed of network formation.[8] Economic development of the simulated world is captured in terms of the *number of merchants*, which is a proxy for commercial development, the *share of ships sailing*, which is a measure of the importance of long-distance maritime trade, and the *number of merchants in towns with foodstuffs specialisation*, indicating the expansion of trade into the rural eastern regions.[9] A measure of welfare is the *wealth of the leading network*, indicating the economic success of a kinship network. It can also be seen as a proxy for the monopoly rent that can be earned.[10]

7 The "leading" family network is defined as the largest (in terms of head-count) group of merchants of the same dynasty.

8 A further measure of structure is the *population share* associated with towns of the leading family network (Ewert and Sunder 2012).

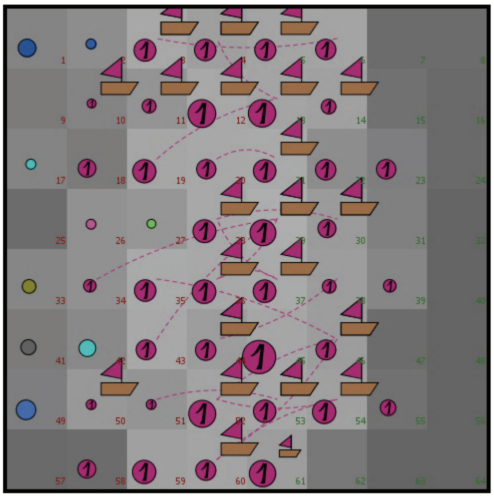
9 Again, additional indicators are measured, for example the *concentration of population*, calculated as the concentration ratio of the population shares for all towns which indicate how unevenly population is eventually distributed across the grid. If the entire population lived in a single town, the concentration ratio would assume the value 1, and it is 0 in the case of a perfectly even distribution across towns (Ewert and Sunder 2012).

10 Alternative measures of welfare are the *per period population-weighted welfare* (of all towns) and the (cumulative) *profit due to long-distance trade*, indicating economic gains of sea trade since the very first period (Ewert and Sunder 2012).

Unless specified otherwise, the measures refer to the final period of each run ($t = 600$). As the model contains stochastic components – such as the initial placement of merchants or the noise in their price beliefs – outcomes of the simulation may not be deterministic. In Table 1 below means of the indicators for the baseline scenario on the basis of 250 replications are presented along with percentage deviations for all other simulated scenarios.[11]

The baseline scenario predicts the emergence of a network-based trading pattern with a dominant leading family in the majority of cases. With an average of 0.58 the network density is quite high and mostly due to the single leading network (99 per cent), which indicates a high degree of network organisation among merchants. Furthermore, this leading role of one family network remains quite unchallenged over the course of time: the leading merchants' network of period 400 will be in the same position in 89 per cent of the cases in period 600 as well. Networks are formed considerably early: in the median case, a family network of (at least) five merchants can be observed for the first time in period 72. The map shown in Figure 2 represents a typical outcome of the simulation model after 600 periods.

Figure 2: Baseline Scenario



Plot of grid occupation by merchants in the final period (t = 600) for the baseline scenario. Merchants (circles) labeled with a 1 belong to the leading family network. Brighter fields correspond to a larger population size of the respective town.

[11] Of course, the mean may not necessarily reflect the "typical" outcome if the underlying distribution is not unimodal. For a 95 per cent confidence interval of the mean indicators within the baseline scenario see Ewert and Sunder (2012).

Table 1: Simulation Results for the Baseline Scenario and Alternative Scenarios

	Baseline scenario	Random mapping	Absence of trade privileges	Absence of information asymmetry
STRUCTURE OF TRADING SYSTEM				
network density	0.58	+10 %	−60 %	−2 %
dominance of largest network	0.99	−4 %	−29 %	−1 %
persistence of leadership	0.89	+5 %	−59 %	−2 %
median period of first occurrence of a family network with ≥5 merchants	72*	30*	113*	69*
ECONOMIC DEVELOPMENT				
number of merchants	42.5	+15 %	+2 %	−1 %
share of ships sailing	0.60	+28 %	+17 %	−1 %
number of merchants in food towns	17.02	+28 %	+11 %	−3 %
WELFARE				
wealth of leading network	50142	+22 %	−44 %	−2 %

	Baseline scenario, lower costs of transportation	Baseline scenario, lower cost of transportation for newcomers after t = 400	Absence of trade privileges, lower costs of transportation for newcomers after t = 400
STRUCTURE OF TRADING SYSTEM			
network density	−7 %	−4 %	−67 %
dominance of largest network	−5 %	−1 %	−36 %
persistence of leadership	−8 %	−5 %	−73 %
median period of first occurrence of a family network with ≥5 merchants	64*	75*	112*
ECONOMIC DEVELOPMENT			
number of merchants	+6 %	−1 %	+11 %
share of ships sailing	+19 %	−1 %	+42 %
number of merchants in food towns	+5 %	−3 %	+24 %
WELFARE			
wealth of leading network	+1 %	−4 %	−42 %

Mean values of 250 replications of each scenario. For scenarios other than the baseline scenario percentage deviations from the mean values of the baseline scenario are given.
* This value is the median period (rather than a percentage change) and does not correspond to $t = 600$.

Simulation results of the baseline scenario match quite well some of the major characteristics of demographic and economic dynamics observed for medieval Northern Europe. Both political integration of the Baltic regions and conversion to Christianity of the Slavic people were important prerequisites to the economic development of the once sparsely populated coastal areas and their hinterland. Numerous villages and towns then were founded along the Baltic coast between Lübeck and Reval/Tallinn until the late thirteenth century. For migrants of the more densely populated areas in Western Europe, new settlements in the Baltic revealed much better economic conditions and offered them the opportunity to begin a new life. More importantly, along with the foundation of Lübeck in 1143/1158 AD, the Western European concept of making the classic medieval town a law-protected permanent market was transferred to the Baltic region. Based on this concept, within only a century all important Hanse towns along or near the southern Baltic shore either were founded or received municipal law.[12]

By 1300 AD however, migration from the West into the Baltic region was almost completed, whereas the economic expansion of these newly founded towns and their hinterland was already under way. Exactly in this early stage of the history of the Hanse, and presumably also because of these developments, Northern Europe saw an unprecedented economic take-off. Hence, how does an emerging network structure affect economic development and welfare? In the final period of the simulation there are 42 merchants on average, i.e. two thirds of all towns have a merchant. Since, on average, 17 of them occupy food towns on the grid (i.e. about half of the 32 possible towns), expansion to the agricultural regions does occur to a considerable degree in the baseline scenario. On average, 60 per cent of all ships, most of which belong to the leading family network, actually are sailing in period $t = 600$. Thus, long-distance maritime trade is quite important in the baseline scenario. The welfare measure of the model can hardly be interpreted in absolute terms, but what can be seen is an increase in the early stages of a simulation run and a persistence of this level thereafter. Such a pattern of development is totally in line with the qualitative historical evidence for the economic development of the Baltic region from the twelfth to fifteenth centuries (Ewert and Sunder 2012).

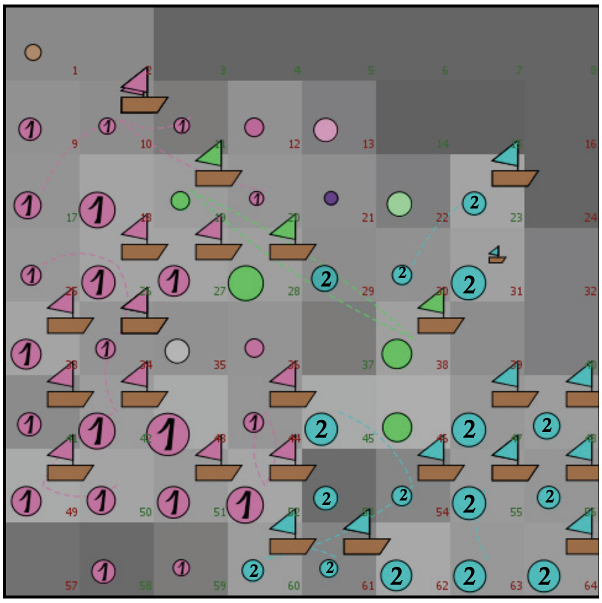
3.3 The Formative Role of Geography

To measure the impact of the clear-cut division of the grid into western commercial and eastern agricultural regions on simulation results, a variant of the baseline scenario is tested, with a randomised distribution of resources and

12 For example Riga (1201 AD), Rostock (1218 AD), Danzig/Gdańsk (1224 AD), Wismar (1229 AD), Stralsund (1234 AD), Elbing/Elbląg (1237 AD), Stettin/Szczecin (1243 AD), Greifswald (1250 AD), and Königsberg/Kaliningrad (1255 AD) (Hammel-Kiesow 2000).

production opportunities at the outset of each replication. Concerning the structure of the emerging network of trade, simulation runs of this alternative scenario on average produce again a network-based trading pattern, but in this system the evolving family network is more densely structured, more persistent, it attracts more population to its towns and it is also formed considerably earlier than in the baseline scenario – the formation of a first network of five merchants on average occurs as early as in period $t = 30$. This notwithstanding, a situation of two (or more) distinct groups of merchants having divided the market proves to be more likely with this random map layout, as on average the dominance of the largest network is by about 4 per cent lower than in the baseline scenario. Figure 3 depicts an outcome of the market division by two merchant families.

Figure 3: Scenario with a Random Map Layout



Plot of grid occupation by merchants in period t = 600 with an initial random spatial distribution of production specialisation, showing a balanced trading network with two family networks.

Economic performance within such a random spatial distribution of production specialisation is much better than within the baseline scenario. Overall trade is more developed, long-distance trade becomes more important and there is a more pronounced expansion of merchants to the agricultural spots on the grid. Because of the randomised distribution, regions with a different production specialisation are more likely to be located next to each other. This renders the emergence of dominant trading centres less likely, to the effect that the population is more evenly distributed across towns. This in turn is an indication of a more balanced spread of commercial activities and economic development. Global welfare is considerably higher in this scenario, and so is the income of merchants as a result of an (on average) shorter distance to market and hence lower transportation costs.

The significant difference between the random spatial distribution scenario and the baseline case highlights the importance of geography also in the historical course of events, as regional specialisation in fact did differ and might have been crucial for the formation of the Hanse's trading network. Moreover, shorter distances to markets would even have allowed market integration through other means of transportation than the rather costly maritime trade considered in the model. Given the vast spatial extent of Northern Europe, one may better understand why it took more than one generation to build a kinship network for trade purposes. Huge distances had to be bridged, which would have been a much more difficult task without a network. That increasing distances nonetheless slowed down the formation of kinship networks corresponds with the fact that the Hansards, before they attempted to obtain themselves exclusive trade privileges, cooperated with other merchants to benefit from the trade privileges that had been granted to these merchants. This was a strategy necessary to enter the market at first.

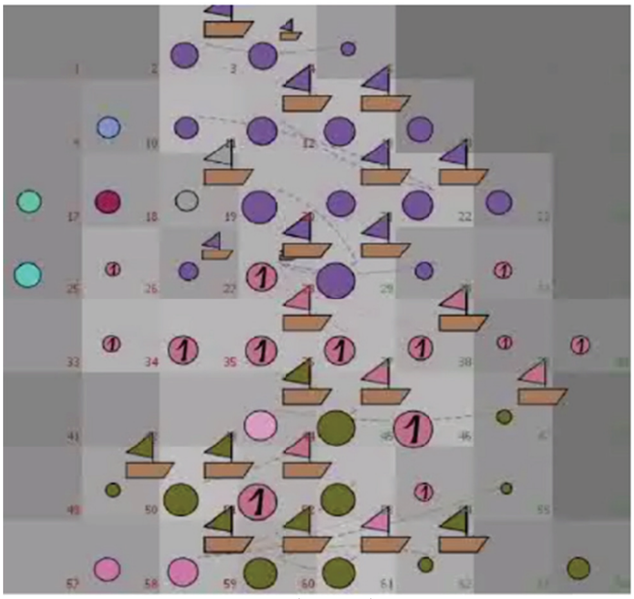
3.4 The Significant Impact of Trade Privileges

Following Douglass C. North, institutions as well as formal and informal rules of a society are important to economic growth – in either fostering or even inhibiting it (North 1981, 1991). Medieval trade privileges may be regarded as such institutions. On the one hand they provided incentives for local merchants to trade, but on the other hand they could also have growth-inhibiting effects by restricting free exchange. Trade privileges could encompass the exclusive rights to trade specific products and commodities, to pay a lower market tax or a lower toll for shipping goods. Rulers assigned these kinds of rights to single merchants or to groups of traders in order to attract trade to their realm. Merchants, as the bearers of such privileges, then usually formed groups, because they sought to prevent the rulers from cancelling or abusing these rights (Greif, Milgrom and Weingast 1994; Streb 2004). An obvious question is thus, how trade would have developed if a certain group of merchants had not been given a competitive advantage over others.

In the considered agent-based model, the institution of trade privileges is represented by a port fee merchants have to pay at markets that do not belong to their own family network. The results of a scenario without such port fees (for any merchant) underline what economic reasoning would suggest. Network formation is much less pronounced than in the presence of such privileges.

Again, a balanced trading system with two family networks emerges (see Figure 4).

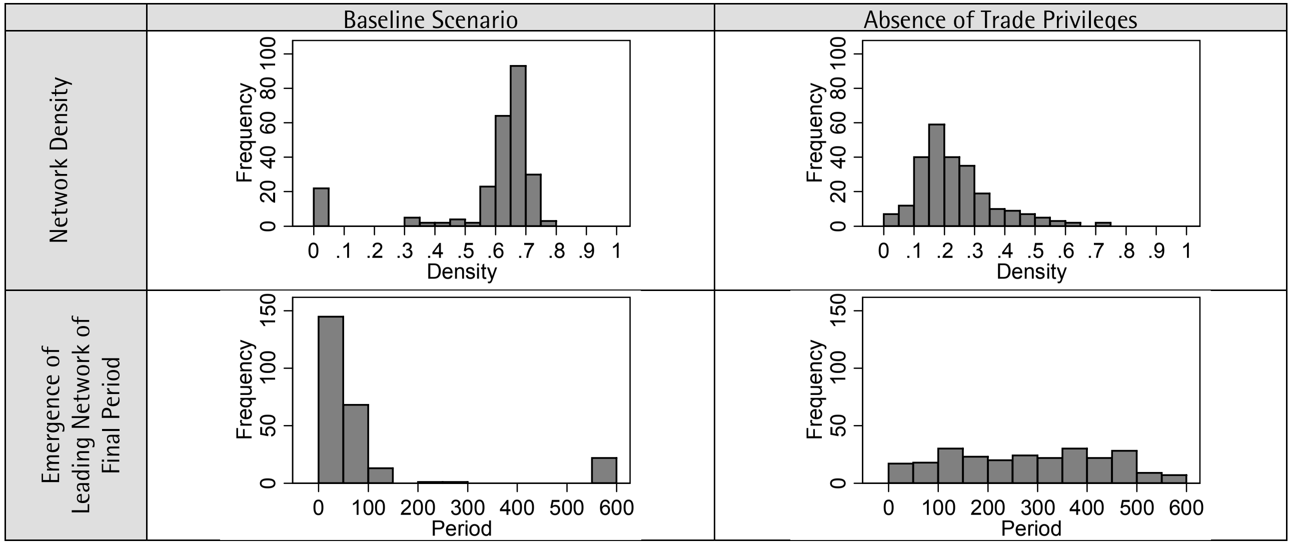
Figure 4: Scenario without Trade Privileges



Plot of grid occupation in the last period (t = 600) in a scenario without trade privileges, showing again a balanced trading system with two family networks.

The networks formed under such free trade conditions are, on average, less densely structured, less dominant, less persistent, and their formation occurs significantly later – on average in period $t = 112$. This is seen in Figure 5 from the frequency distributions of the network density in the final period ($t = 600$) across the 250 replications for both the baseline case and a scenario without trade privileges. Quite similarly, the distributions of the periods in which the eventually leading family network emerged show the marked differences that result from the absence of trade privileges. While in the baseline scenario the leading family of period $t = 600$ emerges within the first 100 periods – in the majority of cases – later evolving families do have a fair chance to dominate in the final period under an open access and free trade regime.

Figure 5: Distributions of Network Density and the Period of Emergence of the Leading Family Network



Shown are the network density (upper panel) in the final period $t = 600$, and the period of emergence of the leading family network of the final period (lower panel) for the baseline case (left) and in the scenario without trade privileges (right). Histograms are based on 250 replications of each scenario.

Simulation results underline that the assignment of extensive trade privileges to a group of merchants was indeed beneficial to this group, insofar as such privileges restricted trade by outsiders. As a consequence, the group could act as a cartel and develop a strong market position. This result strengthens a common explanation of the rise of Hanseatic trade during the high Middle Ages as being first of all the result of valuable trade privileges having been granted to the Hansards at important markets in Northern Europe (Sprandel 1984; Hammel-Kiesow 2000).

In contrast, the lack of trade privileges can also be beneficial for the development of trade. Although the aggregated volume of trade increases only slightly above the baseline level, long-distance trade becomes much more important, and more of the agricultural spots become integrated into commercial exchange. Even though this free trade setting provides strong incentives to both development and expansion of commercial exchange,[13] it has only a marginal effect on the overall welfare of the population. That profits of merchants under free trade conditions are lower than with restricted access to market may be rationalised by a more competitive environment.

3.5 The Coordinating Effect of Information

In the Middle Ages information could be transmitted only slowly. Within the framework of the model, it is possible to analyse if the reliance on kinship-based networks of trade could have helped medieval merchants to handle the information that was relevant to their commercial purposes more efficiently.

In the model, an information asymmetry exists between members of a kinship network ("insiders") and non-members ("outsiders"). Being part of a family network would give an advantage with respect to price information over those not belonging to that network. Therefore, the baseline scenario is compared to a scenario in which such information asymmetries between members of a network and non-members do not exist. Simulation results for the latter scenario show that a quite similar network pattern of trade evolves, with network density, dominance and persistence being only slightly lower. Concerning economic development and welfare, no significant differences to the results of the baseline scenario are observed. At first glance, this seems to be a paradoxical outcome. However, it may be explained by the extensive use of trade privileges under which processing information on those towns not belonging to one's own family network may have seemed pointless to the agents. Although

13 This at least is argued in the economics literature, where pre-modern limited access or exclusive orders (as opposed to modern open access or inclusive orders) of commercial exchange are held responsible for the retarded medieval and early-modern economic development and low growth rates (North, Wallis and Weingast 2009; Acemoglu and Robinson 2012).

network formation is usually considered an efficient method to deal with costly information, this advantage will not turn out directly in this particular setting, where higher gains can always be made from commercial exchange with family members.

This notwithstanding, trade privileges in general reduced the cost of gathering and processing information and thus fostered both the establishment and tightening of kinship networks for trade. Close kinship bonds were viable means to solve the obvious information and coordination problem that cartels usually face. This in turn helped the Hansards also to maintain their trade monopoly. Cost efficiency of a kinship-based network organisation was thus not the only reason for them to stick to this kind of trading pattern in the late Middle Ages (Ewert and Selzer 2007, 2010). It rather seems likely that forming an effective cartel was a crucial motif for their choice of a kinship-based organisation very early on. And it may also explain why early Hanseatic merchants soon abandoned their cooperations with other groups of merchants, e.g. with traders from the Isle of Gotland (Hammel-Kiesow 2000).

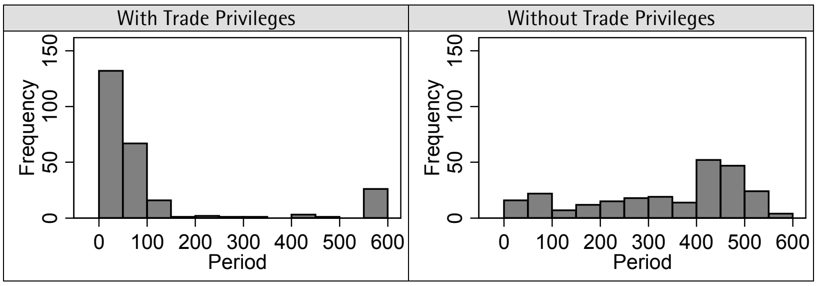
3.6 The Meaning of Transportation Costs

One of the most prominent conclusions of Douglass C. North concerning the "Commercial Revolution of the Middle Ages" is that the commercial rise of medieval Europe was mainly caused by a significant decrease in transaction costs, whereas the so-called "Industrial Revolution" of the nineteenth century is assumed to have been fostered mainly by rapidly decreasing production costs (North 1981, 1985). Transportation costs are a large part of transaction costs, if one considers medieval transportation technology and the huge distances the Hansards had to bridge.

To measure the impact of transportation costs a scenario is run in which transportation costs are reduced to the half of their original value. A comparison of the results of this scenario with those obtained from the baseline scenario confirms how important costs of transportation were for the emergence of trade, for its pattern and development, and for welfare as well. Again, a network-based exchange structure emerges, but this network is less densely structured, less persistent and less dominant. More importantly, a reduction of transportation costs would significantly promote trade development and also increase profit opportunities for merchants. However, due to a higher degree of competition in such a setting the monopoly rent merchants could extract from consumers would not be much higher than in conditions of higher transportation costs. The overall welfare level of the population would be higher indeed, but only by about 2 per cent.

It can also be tested what would happen if only new groups of merchants ("newcomers") would profit from lower transportation costs. This scenario models a technological shift that is only available to those entering the market after a certain time period (t = 400). In the Hanse case this setting became reality, when in the late fifteenth century Dutch merchants were able to challenge the Hansards' monopoly of wheat trade in the Baltic, simply because they were in possession of bigger ships that could carry wheat at lower costs. The emerging pattern of trade in this scenario would also be less network-based, but with smaller deviations from the baseline scenario than before. Furthermore, trade would grow by a lesser amount, and both merchants' profits and global welfare would be more or less on the same level as in the baseline scenario. This is again an indication of the competition-preventing effect of a kinship-based trading structure in the presence of trade privileges. As such a pattern usually emerges quite early after the initialisation of the model (see Figure 6), it usually cannot be broken up by a later decrease of transportation costs. The persistence of the leading network even though it is technologically backward thus points to a lock-in situation.

Figure 6: Emergence of the Leading Network after a Technology Shift



Histograms of the period of emergence of the leading family network of the final period in scenarios with a shift in technology (lower transportation costs for newcomers after period t = 400), according to the existence of trade privileges. Transportation costs are reduced by 50 per cent for newcomer families only. Calculations are based on 250 replications of each scenario.

Another indication of path-dependency is provided by a scenario in which trade privileges are lacking. In this case a decrease of transportation costs for later newcomers yields a much less pronounced network-based trading system, with network density decreasing by about 67 per cent on average. More importantly, the persistence of the leading family network would be much lower in comparison to the baseline case of the previously discussed scenario in which trade privileges existed. The finally leading family network often belongs to the newcomer group, i.e. it emerged after the technological shift in period t = 400 (see Figure 6). In such a setting economic development would improve substantially, with an increase in the number of merchants by 11 per cent. In particular, the number of merchants in "the East" would rise by 24 per cent. Long-distance trade would gain in importance, and welfare would be slightly higher. In addition, long-distance traders could make larger profits in such a setting, whereas – due to stronger competition – the opportunity to earn a monopoly rent would be lower.

These results foster the aforementioned interpretation that trade privileges were the key vehicle to form closed networks, which cannot easily be broken up once established. Much of the literature sees transportation costs at the core of the commercial success of the early Hansards. Verly early on, they used larger ships (the *Kogge*), which reduced unit costs of transportation. There is also historical evidence confirming that both trade privileges and transportation costs were linked to a certain degree. In this way the Hansards were able to squeeze Flemish traders out of the emerging Baltic markets (Hammel-Kiesow 2000). For the Flemish the profitable opportunity to take eastern goods back to the West when they traded on these eastern markets was deterred by the merchants of the Hanse. As the bearers of the exclusive right to ship and trade goods from the East, Hanseatic merchants profited from decreasing costs per voyage in comparison to their competitors when trading on western markets, because their ships could be loaded with cargo on both trips of a voyage. The various scenarios in which transportation costs are reduced show that this kind of technological shift can yield results quite different from those of the baseline scenario, but only in the absence of trade privileges. For this reason it makes sense that Hanseatic merchants – even in the late Middle Ages – were so keen on keeping their extensive trade privileges, e.g. in Bruges, even though other markets, especially Antwerp, had developed in the meantime and began seriously to compete with the economic leadership of the Bruges market towards the end of the fifteenth century (Selzer 2010). Up to this time, Hanseatic merchants also did not have to worry about new technologies opening up to potential competitors inasmuch as their fully established trading network was stable enough for them to dominate trade even if they may have faced higher transportation costs than some of their competitors.

4. Does Agent-Based Simulation Help to Understand the Emergence of Medieval Maritime Trade Systems?

4.1 Insights from Simulation Regarding the Hanse Case

First of all, simulation runs of the considered agent-based model of maritime trade show that modelling and simulation helps to explain the formation of the Hanse's network-based system of long-distance trade and its persistence for quite a long time, and to understand why it finally began to erode at the turn of the sixteenth century. It seems though as if these developments were a logical and necessary result of the environmental conditions of medieval long-distance trade.

Although some basic features of medieval maritime trade are incorporated, other details are nevertheless missing from this model. A way of tailoring the model better to the Hanse example would be to implement a certain number of trading centres as key markets, which would then play an important role in long-distance trade from the very beginning, instead of letting such "hot spots" of trade emerge by the simulation itself. Such a setting would model the Hanseatic case more accurately, as the leading markets of medieval Northern Europe were the places where Hanseatic merchants could obtain extended trade privileges, which in turn became the basis of their kinship-based trading system. It is also possible to extend the town grid to more than the 64 locations of the present version, thus providing space for more merchants. Efficient cooperation in closed and dense networks is usually limited to a certain number of members. Once this critical mass is exceeded, a network's properties of both efficient coordination and enforcement of fairness among members will disappear, because costs for coordination will rise exponentially and a fraud will be less likely detected.[14] One hypothesis is thus that with a wider grid (i.e. in a larger world) it is more likely to observe the emergence of network-based trading patterns that consist of different family groups of merchants.

While the model is not primarily designed to explain economic growth and the development of the standard of living in Northern Europe in the Middle Ages at large, it nevertheless allows to draw some tentative conclusions on the contribution a trade cartel like that of the Hansards made to the economic development in the Baltic in late twelfth and thirteenth centuries. Was the quasi-monopoly of Hanseatic merchants a necessary prerequisite for triggering a "Commercial Revolution" in this region? This is an important question, even more so, because the persistence of this cartel that restricted competition was partly guaranteed by its kinship-based internal structure. Would Northern Europe have experienced its commercial expansion and economic boom of the high Middle Ages also on the grounds of a different and perhaps more competitive trading system?

In the baseline scenario the economy develops to an advanced degree, in the sense that long-distance trade becomes more important and expands significantly into the less developed, agricultural regions. Welfare increases considerably at the time when the network is established, though it does not increase much further afterwards. This finding matches quite well the qualitative historical record. As described above, many towns were founded in this region and trade improved significantly. It stands to reason that towns must have been rich if large cathedrals could be built there.

What cannot be proven with archival evidence is how rapid the economic take-off was in the Baltic and to which degree the economy of Northern Europe

[14] See on this in general Greif (1998; 2000; 2002a), and for the Hanse Ewert and Selzer (2007).

had actually grown. Comparing the baseline scenario of our simulation with the scenario of a randomly assigned specialisation of towns – in which network formation occurred much faster – it may become clearer why the process of economic development of the Baltic region in twelfth and thirteenth centuries took a century's time, and why this economic take-off, even though being quite impressive, presumably did not match the economic development of Western Europe or that of the Mediterranean. A clear-cut division of resources and production facilities combined with huge distances, as it was the case for medieval Northern Europe, was obviously a severe obstacle to the development of long-distance trade. In the simulation, network-based trade tends to be more pronounced in the vicinity of the border between commercial and agricultural regions as a result of distance-based transportation costs. This in turn highlights why Northern Germany and the town of Lübeck – by occupying this position "in between" areas of different economic development – were so important for the emergence of the Hanse.

4.2 Potential Reasons for the Institutional Divergence within European Medieval Trade

The institutional arrangement of maritime long-distance trade in the Mediterranean had developed about a century earlier than the Hanse's system of network-based trade in the Baltic. To be correct, in the Mediterranean case one would have to speak of an already existing system of trade that became more and more dominated by Christian merchants, most of them of Italian origin. In the late eleventh and early twelfth centuries, as a concomitant of the crusades, merchants from Italian port cities such as Venice, Genoa, and Pisa took over much of the already existing exchange of commodities between Southern Europe on the one hand and Palestine, the Arab peninsula, and North Africa on the other hand. Subsequently, and fairly rapidly, they could restructure trade in the Mediterranean on the basis of exclusive trade privileges granted by the Byzantine Empire and the newly founded Crusader States in Palestine.

Compared with the Hanse's network organisation of trade in Northern Europe, the pattern of maritime long-distance trade in the Mediterranean was different in many respects. Of course, kinship and personal bonds were important among merchants in the Mediterranean, too, but overall quite early trade was characterised much more by law-based institutions and third-party enforcement than by self-enforcing institutions. Italian merchants made proper use of formal contracts like the *societas maris*, *commenda*, or *collegantia*, which allowed them to raise funds for their risky overseas commercial endeavours and to spread commercial risk across the partners involved in such a trade. Later on, Italian merchants were also the first to form larger trade companies, and as merchant bankers they developed a far stretched banking system through which trading partners – with the help of bills of exchange – could transfer money all across Europe and pay cashless for their obligations. Formal contracts could be credibly enforced because of the responsibility of Italian town communities for commercial affairs and because contracts usually were certified by a notary public (Greif 2000a, 2002b). So, why was there a significant divergence of institutional development of medieval maritime long-distance trade between the Baltic and the Mediterranean?

Even though the agent-based model of medieval trade presented in this paper was designed to mainly match the Hanse case, simulation results nonetheless may help to understand a little better why the institutional arrangement of maritime long-distance trade in the Mediterranean developed so differently. At least some tentative conclusions can be drawn from the findings obtained in the analysis of trade in Northern Europe.

One result for the Hanse case was that a clear-cut division of geographic specialisation slows down both network formation and economic development. Such a pronounced spread of resources cannot be found in the Mediterranean around 1100 AD. And compared to Northern Europe there were not such pronounced differences in economic development, either. Italian merchants accessed already well-developed markets when they entered the eastern Mediterranean in the early twelfth century. And they were soon backed by trade privileges for their trade in the Byzantine Empire and in the newly founded Crusader States in Palestine. Moreover, as a heritage of the Roman Empire in classical antiquity the whole region was still characterised by the Roman law, irrespective of the religion of merchants. Since also Muslim as well as Jewish traders were well acquainted with formal contracting along the lines of Roman law, there was not much of a juridical differential. On the contrary, the more or less diffuse knowledge of Roman law in the Mediterranean may very well point also to a path-dependent development that favoured choosing formal contracting for trade.

The much smaller geographic differential in economic development likely had positive repercussions on trade in general. And this may explain why in the Mediterranean more complex and more formal institutions of trade emerged much earlier. In transaction cost theory economies of scale are assumed to be an important factor in the organisation of commercial exchange. The bigger amount of population that lived along the shores of the Mediterranean and its hinterland naturally generated a much bigger volume of trade. This might have thus called for a more formal structure of exchange and for formal solutions of enforcement as well. Exactly these necessary economies of scale in the organisation of trade were realised, because the amount of traded commodities had very early on exceeded a threshold below which a formal institutional arrangement would have been too costly. With bigger volumes traded also more capital could be accumulated, which then was reinvested in even bigger commercial endeavours.

Finally, a further potential reason would stem from the differences in trade privileges and market organisation. On the ground of their exclusive trade privileges, Hanseatic merchants formed a stable cartel through which they were able to monopolise trade in the Baltic. A similar behaviour of Italian merchants in the Mediterranean cannot be observed. Merchants from different Italian towns did not share privileges as Hanseatic merchants did. Instead the Italian merchants always competed for trade privileges, and in the long run this competition was settled by a de facto division of markets with Venetian merchants predominantly trading in the eastern Mediterranean and the Black Sea and Genoese merchants mainly operating in the western Mediterranean. It goes without saying that this sort of competition provoked attempts of the authorities of Italian port cities to provide their merchants with formal institutions, because the town communities always had strong interests in backing their compatriots within this commercial competition.

4.3 Why Use Simulation in Historical Research?

Modelling and simulation are definitely not among the standard techniques that are usually used in historical research, especially not in the field of medieval history. Agent-based simulation, for instance, has previously been applied in demographical research, sociology, and economics (Doran 1996; Epstein and Axtell 1996; Epstein 1999; LeBaron 2000; Billari and Prskawetz 2003), but rarely in historical research.[15] How can this reluctance of historians to make use of such a powerful tool be explained? Historians typically have strong reservations concerning the use of formal models, because they doubt that a complex historical reality could be captured within a simple abstract model. Of course, a simulation model cannot – and probably should not – cover all aspects and details of a historical phenomenon. It should be restricted to key parameters, in order to obtain general insights into structure and dynamics, but choosing what is relevant and what can be ignored is certainly a difficult task. However, for quite a while now the use of formal models and quantitative methods to test these models empirically has been adopted by scholars in at least particular fields of historical research like economic history, for instance. The so-called "New Economic History" began to flourish in the early 1960s, and this scientific paradigm is built upon the explicit use of economic theory to explain the phenomena of the past, the formulation of (causal) hypotheses and the test of these hypotheses with historical data (Sarrazin 1974; 1980). So, from this side,

[15] Cf. Ewert (2007) for some more general considerations concerning the issue and Ewert, Roehl and Uhrmacher (2003; 2007) for an application to long-term demographic and economic consequences of mortality crises in pre-modern urban communities and the assessment of strategies and devices to manage such crises.

there should not be any real problem in using a modelling approach even for the analysis of medieval phenomena.

Hence, modelling in general and quantification in particular appear not to be the major objectives in using simulation in the context of historical research. The major problem of a methodological transfer is that historians and social scientists (including the economists) are looking at historical events and processes in a completely different way. Whereas social scientists usually are interested in deriving common patterns and certain determinants of development, historians always point to the fact that history by definition is unique, and therefore historical events and processes cannot be explained on the grounds of any ahistorical abstract model. And in fact, they are absolutely right in doing so, because the singularity of past events and processes cannot be denied, of course. As a consequence, it is straightforward to say that history always happens only once and can thus not be repeated. This notwithstanding, repeating history is not what simulation approaches are really aiming at. Simulation adds to the possibilities of analysis on the basis of formal models. Whenever formal analysis is an appropriate approach to history, simulation should also be acknowledged as an acceptable and viable technique. Therefore there are good reasons why resorting to simulation methods in historical research may be very well justified. Simulation allows scientists to construct alternative scenarios to what has been observed in reality, scenarios which could have happened in the past as well. And such “what-if-scenarios” are useful to put known historical facts into a well-defined context (Fogel 1970; Sarrazin 1980; Ewert 2007). Simulation is thus not an alternative means to historical interpretation. It is, in contrast, a method to foster interpretation, especially if empirical data are scant or almost completely missing, as is the case with the early maritime long-distance trade in medieval Europe.

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