Economics Department

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The Sea Loan

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Changes in Information and Optimal Debt Contracts: the Sea Loan

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Abstract

In this paper the relevance of public and symmetric information on the enforceability of contracts will be analyze. In particular, it will examine an historical contract, the *sea loan*, which was used to finance long-distance maritime commerce from the times of ancient Greece to those of the Medieval Ages. A single economy general equilibrium model is set up in which, under certain restrictions, the *sea loan* emerges as the optimal individually rational contract and it is claimed that these restrictions were very likely to be satisfied by the economy of that time. It will also examine the substitution of this kind of contract— which was enforced by a coercive power relying on public information— by the *commenda*. This occurred because of the new supply of symmetric and public information, which led an efficient improvement in the sense that both the navigation and the commercial risks were shared, while in the former contract the merchant undertook all the commercial risk alone.

Keywords: Asymmetric information, commenda, contracts, credit, Economic History,enforceability, institutions, insurance, risk, sea loan.
JEL classification numbers: D81, D82, N23, O17.

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1 Introduction

In this paper I will analyze the *sea loan* contract. This was a contract that financed long-distance maritime commerce from the times of ancient Greece to those of the tenth century. After this long period, it was progressively substituted by the *commenda.* These two contracts differed only in that in the *commenda* both the commercial and the navigation risks were shared, while in the *sea loan* the merchant bore the commercial risk alone. Indeed, the former established a division of profits, deducted travelling charges, such that the merchant received $\frac{1}{4}$ for his work and the investor the remaining $\frac{3}{4}$, while the latter contract established a fixed contingent transfer(from the merchant to the investor) if the ship came back to port safely, regardless of the profitability of the venture, that is, despite the commercial risk, and a transfer equal to the value of the rescued cargo when there was a case of non-safe arrival. Given that non-safe arrival usually meant the complete loss of the cargo, the merchant was explicitly excused from repayment in this case.

The most remarkable feature of the *sea loan* is that it provided insurance and credit within the same contract. At first glance, it appears that in today's world credit and insurance are supplied separately. However, most legal systems allow for some insurance in debt contracts, in the form of bankruptcy. Standard debt contracts are characterized by fixed repayment when the firm is solvent and a declaration of bankruptcy if this fixed payment cannot be met, allowing the creditor to recoup as much of the debt as possible from the firm's assets. This is the nature of the *sea loan*, except that the declaration of bankruptcy is unnecessary since it is obvious.

As far as I know, the *sea loan* has not been examined from a contract theory perspective. However, my model is close in spirit to that of Townsend(1978) in that the merchant can be viewed as a firm engaged in an investment project with random return s. Agent 1(the merchant) can issue an asset to agent 2(the investor) where the asset is some claim on the return of the project. The problem, then, is to determine the type of transfers that are mutually agreeable to both parties. Townsend assumed that the realization of the return is available to only one party of the contract but that the range of possible contingent contracts is limited to those which are easily verified by both, and at a cost. He developed a model in which the resulting contract is a bond which promises to pay some fixed constant unless bankruptcy is declared by agent 1. In that event, verification(bankruptcy) costs are incurred, and something less than the fixed yield is paid. This payment may be negative. My model for the *sea loan* considers the two limiting assumptions on (contingent) verification cost: in the case of commercial business the cost is infinite, or there is no way to verify it, whereas the cost of verifying the safe arrival of the ship is zero, i.e. it is public information. Thus, my result is similar to that of Townsend, except for the information structure that determines the verification set, and for the treatment of bankruptcy. Townsend did not study the functional form of transfers in the case of bankruptcy: he only imposed them to be smaller than the fixed constant(in order that incentive compatible constraints be satisfied). This, however, is not a complete characterization of a standard debt contract.

Regarding bankruptcy, a basic analysis is that of Gale and Hellwig(1985). They proposed a one period model with asymmetric information in the form of observing profits. My model for the *sea loan* differs from theirs in that they assumed observation costs, like Townsend(1978), and did not enter into consideration of risk-aversion. Thus, Gale and Hellwig justify the standard debt contract in terms of observation costs under asymmetric information and risk-neutrality of both agents. They also discuss their problem(a more complicated one that includes the level of investment decision and examines credit-rationing) when the entrepreneur is risk-averse, and they found that the standard debt contract is no longer efficient.

I think that their analysis is not satisfactory in explaining the *sea loan* because their basic assumptions(positive and finite verification costs in all states and risk-neutrality) are not appropriate for the period in which the *sea loan* was used. In my model, asymmetric information, with no possibility of verification, concerns only the commercial outcome, and, hence as with both of their models, the transfers are fixed regardless of its realization—transfers cannot depend on private information in a one period model when the asymmetric information is of the type of observing and revealing the realization of unique random variable. However, the safe arrival of the ship does not imply verification costs and therefore a contingent transfer should be established. This should not be viewed as the impossibility of fulfilling a fixed payment (which is no longer the optimal), but as the efficient contingent contract which determines a payment that must be feasible.

The aim of this paper is to explain why the *sea loan* lasted for such a long period and why it was substituted afterwards. In order to do this, I will create an artificial economy in which, depending on a key parameter, either the *sea loan* or the *commenda* emerge as the optimal individually rational contract. I claim that my model reproduces the historically observed economy in its most relevant features, and that this key parameter, measuring the informational asymmetry, changed during the Commercial Revolution of the late Middle Ages. Optimality, then, would justify both its very long use and its substitution: an efficient contract is used until some parameters in the economy change so that it is no longer efficient.

The organization of the paper is as follows. Section 2 reviews the historical evidence and provides the relevant facts. Section 3 places these facts in an economic model, which is solved in section 4. Section 5 introduces an informational technology improvement which render the *sea loan* no longer efficient, and section 6 concludes.

2 Historical facts

The *sea loan* was a contract that provided the capital required for a ship to undertake a commercial long-distance voyage, with the particularity that the lender bore a part of the navigation risk. The agreement went something like this: a person who had money or merchandise(investor) gave it to a merchant— a person who was able, capable and willing to perform in long-distance commerce— in return for some contingent transfers. Subsequently, the merchant sailed and traded. In the likely case that the ship was sunk by a storm, fire or pirates—and the cargo lost, the contract established a zero transfer, i.e. it partially insured the merchant against the navigation risk.[1] If, on the contrary, the ship arrived safely in port, the merchant had to give back a positive fixed amount which covered capital and interest(caput et prode), regardless of the profitability of the venture, that is, the commercial risk(see appendix A for historical records of a *sea loan*).

The first record of a *sea loan* dates from ancient Greece, when it was referred to as *nautika* or *nautikos tokos*. The Romans, at the end of the Republican period, also adopted it, calling it *fenus nauticum* or *pecunia traiecticia*. It was used until the middle of the thirteenth century in the Mediterranean Sea when it was replaced by the *cambium maritimum*.[2] However, before this "nominal" substitution took place, the primacy of the *sea loan* in financing long-distance commerce was questioned by the *commenda*—a pioneering contract in which both the commercial and navigation risks were shared; in fact, the *commenda*, which dated from the end of the tenth century, was the most popular form in the thirteenth century.

[1] In fact, it did not give as much insurance as the information constraints permitted, which is a negative transfer in the case of sinking, but the minimum required for the realization of profits. This is confirmed by the *respondentia*, an advanced kind of *sea loan* which clearly set the transfer in the case of sinking equal to the realization of profits. The *respondentia* took into account the possibility that the ship ran aground on entering a harbour, but that the cargo was salvaged before the hull was broken up and stipulated that the loan would be repayable upon the safe arrival of a certain ship or most of its cargo. A clause similar to this also appeared in contracts dating from the ancient Greece (see appendix A.1). The loss of the ship, then, could not be used by the owner of the cargo as a pretext to repudiate his debt. This suggests how insurance, to this extent, in a *sea loan* was a necessary requirement and was not the aim of the contract.

[2] The *cambium maritimum* involved an advance of funds repayable in another currency, instead of the same one, contingent upon the safe arrival of the ship. In this new form interests on the loan could be hidden by making repayments in another currency at a given rate of exchange. Recall that in 1236 the Pope Gregory IX, in the decretal *Naviganti*, formally condemned the *sea loan* and similar contracts as usurious. It is clear that the nature of the *cambium maritimum* is that of a *sea loan*.

The *sea loan* lasted for more than 15 centuries. Obviously, many things changed over such a long period. However, from the ancient Greece to the eleventh century a constant regarding commerce hold: trade was heavily limited. At this time an "aureas mediocritas" rather than innovation, in economic terms, was fostered. Nonetheless, commerce did exist and long-distance maritime commerce was its most fascinating branch, practised only in the most developed and free cities, by full-time merchants. Hence, the *sea loan* should not be analyzed in the rigid perspective of either traditional Greek scholars or of feudal justice(see among others, Birdzall and Rosenberg (1986), Cohen(1992), Lane(1987), Lopez(1960), Luzzatto(1961) and Mejier and van Nijf(1992)). "Just price" and "just wage" were set by tradition, costumes and law, whereas merchant trading contracts were established by negotiation and prices tended to clear the market. This applied even more for the late Middle Ages, where a commercial revolution took place.[3] Innovation, then, spread to all areas, especially to the organization of business, as it is shown by the *commenda*.

The nature of long-distance maritime commerce also remained unchanged in its most relevant features during these two periods (see Cipolla (1980), Cohen(1992), de Roover(1963), Di Nero and Tangheroni(1978), Lane(1944), Lopez(1943) and (1976), and Luzzatto(1943) and (1954)).

- It was a risky activity.

  The probability that the ship would wrecked was high since the navigation tools and the quality of ship-building were poor; besides, attacks by pirates or enemy ships were frequent. Moreover, this was not the only risk a merchant faced: the commercial risk was also high. In contrast to today's practice, the cargo was not sold before

[3]Interest rates in the twelfth century in Venice—one of the most important and active cities—were set by market conditions and they were not considered as "usurious" in the negative way the Church claimed. This is shown in numerous documents of debt(see Morozzo della Rocca and Lombardo (1940)) by the qualification of common("secundum usum nostrae terrae") to an annual interest of 20 percent(with a guarantee of pledge and with a clause of double capital and interest in the case of a delay!), and, what is more, there is evidence that these clauses were applied.

shipping; hence, when the merchant set sail he did not know the price at which he would be able to purchase the merchandise nor the quantity that he would be able to buy, nor did he know for how much he would sell it when he came back to the original port. There is strong evidence that the commercial risk was high during the whole period.[4] However, there is also evidence that this activity was very profitable regardless of the commercial outcome.

- The requirement of capital was high.

  Trading by sea involved high fixed costs, including the equipping of a ship. Thus, it was likely that the merchant (the person who had the ability and the will to commerce) did not have enough capital to float a ship, or in the case that he had some capital it might be that he wanted more in order to spread the fixed costs (e.g. an anchor, the crew's wages or the possibility of travellers' death).

- Capital was scarce.

  Ventures were very big with respect to resources. In fact, a single voyage was financed by many investors(not only to diversify risk, but because of the lack of capital). This shortage of capital in the economy as a whole cause interest rates be high.

  Moreover, there is evidence that most investors were not rich.

- There were poor informational flows—the rise of travelling merchants.

  The flow of information was very poor. It was scarce and it took a great deal of time. This was because the cost of transportation was high (there were no independent and rapid mail services) so that information was transmitted by the same ships that were trading; moreover, transactions were not frequent and they took

[4]Even after the eleventh century when, as Lopez(1976) pointed out, a commercial revolution started with an increase in the number of transactions, an improvement of commercial techniques and the flow of information, a delay of no more than a few months in the arrival of the convoy from Alessandria to Venice in 1225 made the prices of pepper and other species increase greatly all over the West.

place in markets which were not well-known. Given that there was no communication, it was impossible for two merchants(subordinated or not) in different markets to employ a shipper, and thus save themselves the risk, inconvenience and time to travel. Furthermore, it was impossible for any person other than the traveller to carry out his affairs: business needed quick decision-making based on the information available to the travelling partner. In conclusion, a sedentary merchant could neither communicate with another merchant in a long-distance market nor send a subordinate with complete instructions; as a result, he himself had to travel and trade.

- There was asymmetric information—no separation between ownership and management.

  The realization of profits[5] when ships did not sink were neither verifiable nor observable given the state of informational technology before the Commercial Revolution. The travelling merchant was the only person to know the true value of the realization of the commercial outcome; no one else could verify either how much he had paid for a merchandise in a long-distance(=unknown) market nor how much he had sold it at. Hence, he was the residual claimant, i.e. the one who receives whatever is left from profits after the other agent receives his payoff.[6] However, the Commercial Revolution introduced the development of new techniques such as

[5]Profit is used to indicate the amount of consumption goods that was available before transfers were paid.

[6]These impossibilities of control and supervision (from the merchant to the traveller and from the "capitalist" to the merchant) were reinforced by the legal negation of direct representation by Roman law. There was a legal restriction prohibiting a traveller to contract in the name of a merchant or a merchant in the name of another: the consequences of business(debts or profit-sharing) had a legal effect exclusively on the agent and only after concluding his affairs with a third part could he satisfy his agreements with the principal. Thus, the merchant had to be the owner of the capital in order to trade, as well as the owner of profits. This was similar to saying that he was the residual claimant. This was recognized by law, which classified the *sea loan* as a kind of debt contract(a "mutuo"). On the other hand, the lack of recognition of direct representation can be viewed as an effect of the lack of control.

new mercantile book-keeping, which facilitated control and provided information, bills of land, bills of exchange, etc., which helped to observe profits.

Conversely, the arrival of the ship was public information. Some of the contracts were signed for a round trip(especially the oldest) whereas some others established a one-way trip. In any case, the safe arrival of the ship was publicly observable by the investor or a reliable person of his own who was in the port of arrival. However, the sinking or the attack of a ship was not directly observed by the investor, who did not travel with this ship, and, what is more, given the structure of the contract(no repayment in the case of a sea disaster), the merchant had an incentive to claim that there was such a disaster. He could have simply disappeared but this would have implied giving up his family, his possessions and the opportunity to complete the trade(since operating in long-distance commerce required a legal structure not available in many places; in turn, people in these places frequently treated foreigners with suspicion). He could have changed the cargo to another ship and then sunk it[7] but on coming back to the home port it would have been "difficult" to explain that the contracted ship had sunk and the cargo been lost while the merchant and the whole crew had been miraculously rescued by a ship full of profitable merchandise, though with no crew. In conclusion, the realization of the sea risk was directly or indirectly observable by the investor and verifiable, because of the relatively developed political system.

- There was a coercive power—verifiability.

  This contract was developed in well organized economies, where the state had certain powers. In particular, this institution was able to act as a coercive power, and thus to enforce contracts based on public information. Therefore, there was no distinction between observability and verifiability.

[7] Recall that the value of a ship was low in comparison with the cargo and its equipment.

- It was a complex activity— full-time merchants.

  Our merchant needed to know about prices, weights, coins, mercantile practices and law, like any other merchant, but when trading in long-distance markets he had to extend his knowledge to the weights, coins and practices(including the language) of remote markets. Moreover, ours was a travelling merchant and hence a seaman; this necessitated training and much time to travel. Therefore, the travelling merchant had to be a full-time merchant.

In conclusion, this was a full-time travelling merchant who operated in his own name(being the residual claimant) and thus assumed risk and performed in his own interest, all of which was incompatible with being a subordinate.

Nothing leads us to think that agents, either lenders or borrowers, were risk- neutral.[8] In most articles, this assumption is taken in order to simplify calculus. Most of the times it is not misleading since the analysis does not focus on risk-sharing. However, the *sea loan* was a contingent contract which provided insurance only to some extent— it did not cover the navigation risk completely since the merchant consumed less in the case where the ship was wrecked than otherwise. It could be the case that the transfer in the case of a sunk ship was negative, i.e. that both the lender and the borrower agreed that the lender might pay a positive

[8]In fact, history shows an uninterrupted desire for agents to get insured. Investors financed voyages only partially, diversifying through different periods and routes, and shared the property of anchors and ships in order to avoid risk. By their part, merchants diversified through different products and branches of activity. This trend culminated with the creation of the premium insurance. However, this was not until the fourteen century. It is notable that the first record of a maritime insurance premium dated from 1350 when the Commercial Revolution was over and consequently not only had the sea risk dramatically decreased but the number of transactions had increased sufficiently for the risk to be spread completely. This first record is from Palermo and given that Palermo was a secondary centre and that the contract was signed by a Genoese, de Roover(1963) assumed that the premium insurance was known in Genoa some time before 1350.

amount to the merchant, regardless of the loss of the anticipated capital. Thus, assumptions about risk-aversion are fundamental.

Commonly, the investor is assumed to be risk- neutral since competitive markets are also assumed. When the number of operations is large enough(a continuum) the law of large numbers applies, that is, the risk can be completely spread, and hence risk-averse agents can be treated as risk-neutral because they diversify and in this way avoid risk. On the contrary, the number of transactions in the period the *sea loan* was used were very small.[9] In fact, this little commerce was one of the most relevant features of that period. Therefore, assuming risk-neutral agents does not make sense.

3 The model

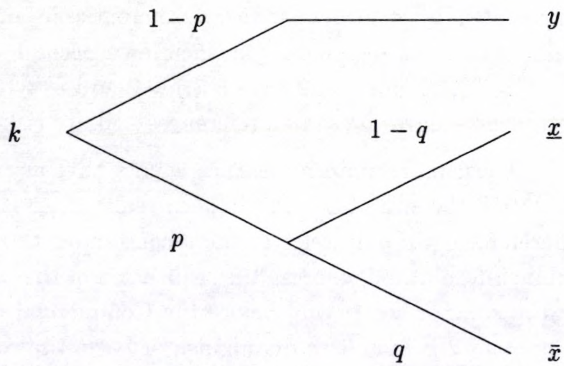
The environment described above can be characterized by a static model. This is a leading assumption in the analysis and it is restrictive. The justification for this assumption is that transactions were reduced to a minimum and were rarely repeated, hence there was no role for dynamic mechanisms. Besides, contracts were signed for only one trip, i.e. a single period.

There are two technologies in this economy: one riskless, say land, and the other risky but more productive, say a long-distance maritime voyage. Both technologies involve two dates, 0 and 1. At the first date, investment is chosen; at the second one, the return is produced. The former technology yields a riskless return of $r \geq 1$ in the second stage for each first-stage-invested unit of the only consumption good in which every thing is measured. The voyage needs k units to be financed and it yields a random outcome $s \in S = \{y, \underline{x}, \bar{x}\}$ with probability $p(s)$, where y denotes the state if the ship is sunk,[10] and $\underline{x}$ and $\bar{x}$ stand for

[9] In other words, ventures in that period were very large with respect to resources. This is comparable to todays' situation for earthquakes in Japan. No insurance company is insuring against these events, because they cannot achieve perfect risk-pooling. I want to thank Ramón Marimón for pointing this out to me.

[10] We can assume $y = 0$ without any loss of generality.

the commercial realization. In other words, there are two kinds of risk: the navigation risk and the commercial risk. First, it may be that the ship sink, and only if this is not the case— which I represent by the pre-state x, the commercial outcome is produced; hence, if $p(y) = p$, $p(\underline{x}) = (1-p)(1-q)$ and $p(\bar{x}) = (1-p)q$.



The voyage is more productive in the sense that

$$\sum_{s=y,\underline{x},\bar{x}} p(s)\, s > k\, r$$

with

$$\bar{x} > \underline{x} > y < k\, r$$

There are two agents, indexed by i and a coercive power called il Comune[11] which defines property rights to such a degree that only voluntary exchange occurs. It also enforces contracts conditioned on any publicly available information, so that there is no distinction between observability and verifiability. Agent 1, the merchant, is initially endowed

[11]Comune is the Italian name for the city-hall, i.e. the government.

with the possibility to undertake the risky project specified above but not with the necessary capital to finance it; hence, if the voyage is financed his endowment at date 1 is the random variable S, which possible realizations are the states s. Agent 2, the investor, is endowed with $k2 \geq k$ units of capital at date 0, and has to decide whether to invest in land or finance the project. Thus, $(k2 - k)r$ is his endowment after financing the project. Let agents 1 and 2 be expected utility maximizers over the single consumption good of the model, and let their preferences be represented by continuous, twice differentiable and strictly increasing utility functions depending on their own second-stage consumption,[12] $U(c_i) := U_i(c_i)$ for i=1,2 with $U'(.) > 0$ and $U''(.) < 0$. In other words, both agents have the same preferences and are risk-averse.

A crucial assumption is that agents have asymmetric information. At date 0 the state has not yet been realized, so it cannot be observed. Therefore, I will only refer to the second date: the arrival of the ship is public information, whereas the realization of the commercial risk is not always so. For the period before the Commercial Revolution, I assume that agent 2 is unable to distinguish between the commercial states, but he knows, and can verify, that these were no smaller than $\underline{x}$.[13] However, during the Commercial Revolution there was an information technology improvement which permitted agent 2 to observe the true state. This change in the observability of the commercial state can be measured by the parameter θ, with $\theta = 0$ for the period previous to the Commercial Revolution and $\theta = 1$ afterwards.[14] Thus, the observable/verifiable commercial state is

$$\max\{\underline{x}, \theta\, s\} \leq s \text{ for } s = \bar{x}, \underline{x}$$

[12] Agents only consume at date 1.

[13] Conceptually, the state $\underline{x}$ is different from the minimum verifiable outcome, say $x_{min} (\leq \underline{x})$. This can be thought as the minimum agent 1 can declare, or, historically, the pledge merchandise.

[14] It is more realistic to assume $\theta \in [0, 1)$ since the Commercial Revolution led to a reduction in the private information concerning the commercial states, but it did not canceled this information asymmetry. However, the following analysis, for the extreme cases($\theta = \{0, 1\}$) is also valid for $\theta \in [0, 1)$.

Note that for $\theta = 0$, the observable commercial states do not depend on the true ones.

Definition 1 A contract(at date 0) for this economy specifies ($\tau(y)$, $\tau(\underline{x})$, $\tau(\bar{x})$), where $\tau(s)$, either ≥ 0 or ≤ 0, is the (ex-post)transfer agent 1 gives to agent 2 when the state is s, for $s = y, \underline{x}, \bar{x}$.

Let $c_1 := c_1(s) = s - \tau(s)$ and $c_2 := c_2(s) = (k2 - k)r + \tau(s)$ denote the consumption of agent $i = 1, 2$ when the state is s, for $s = y, \underline{x}, \bar{x}$, and consequently the voyage has been financed; otherwise, each agent consumes his autarky endowment, that is, 0 and $k2\,r$ for agents 1 and 2 respectively. Note that $c_1(s)$, $c_2(s)$ and $\tau(s)$ are not functions of $s = y, \underline{x}, \bar{x}$—which are parameters— but different variables in each state.

Definition 2 A contract is efficient if there is no other feasible contract, satisfying all the constraints, that yields a higher expected utility for agent 1 for some fixed value of agent 2's expected utility.[15]

In order to show that a contract is efficient, it has to be proven that it is so regardless of the level at which the reservation value of agent 2 ($\overline{U}_2$) is fixed, provided that participation constraints are satisfied. Thus, bargaining-power is irrelevant for the analysis, since the characterization of an efficient point provides a sort of contract regardless of who had a particular bargaining-power.

Definition 3 A *sea loan* is a contract in which $\tau(y) = y$ and $\tau(\underline{x}) = \tau(\bar{x})$.

Definition 4 A *commenda* is a contract in which $\tau(y) = y$ and $\tau(\underline{x}) < \tau(\bar{x})$.

[15] Notice that for a contract to be efficient, it has to satisfy well-defined participation constraints, so that efficiency implies, within this context, individual-rationality. I am interested in this, rather than in all contract curve points, because contracts were established by voluntary negotiation, given certain initial endowments. However, because of notational simplicity, I will assume that performing in oversea trade is always convenient for the merchant, and thus his participation constraint will not need to be imposed. Given that his initial endowment of the single consumption good is zero, his reservation value depends only on the subjective value he assigns to his life, and this is unknown; therefore, I will assume that this subjective value is smaller than the utility he receives by trading since his consumption level is restricted to be positive(see below).

4 Solving the model for $\theta = 0$

I assume $\theta = 0$ for the period before the Commercial Revolution and, therefore, for the analysis of the *sea loan*.

Since transfers go from one agent to the other, feasibility is always satisfied, and the efficient contract solves the following program.

Program 1:

$$\max_{\tau(s)} \quad \sum_{s=y,\underline{x},\bar{x}} p(s)\, U_1\{s - \tau(s)\}$$

$$\text{s.t.} \quad \sum_{s=y,\underline{x},\bar{x}} p(s)\, U_2\{(k2 - k)r + \tau(s)\} \geq \overline{U}_2 \qquad (1)$$

$$U_1\{s - \tau(s)\} \geq U_1\{s - \tau(s')\} \text{ for } s, s' = \underline{x}, \bar{x} \qquad (2)$$

$$s - \tau(s) \geq 0 \text{ for } s = y, \underline{x}, \bar{x} \qquad (3)$$

$$(k2 - k)r + \tau(s) \geq 0 \text{ for } s = y, \underline{x}, \bar{x} \qquad (4)$$

where equation(1) is the participation constraint of agent 2. His best alternative is to invest in land, and, consequently, an optimal contract has to provide him with at least the same expected utility. Depending on his bargaining-power, $\overline{U}_2 (\geq U_2\{k2\, r\})$ will take a particular value, for which the participation constraint of agent 2 must hold with equality, as is implied by definition 2 within my model.

Equation (2) is the incentive compatible constraint for $\theta = 0$, where s is the actual commercial state and s' is the claim of agent 1 concerning the commercial state. Note that for the state y, an equivalent constraint is not imposed, since the safe-arrival of the ship is public information and, hence, this contingent transfer does not have to depend on the revelation of agent 1.

Equations (3)-(4) are the nonnegativity constraints on consumption. It is possible to assume that (4) is nonbinding without altering the surface of the problem: just assume that $(k2-k)r$ is big enough to satisfy the level of maritime insurance for an optimal $\tau(y) < 0$; since agent 1 has already received $k > 0$ from agent 2, he must repay a positive amount in the most profitable states, otherwise his project will not be financed.

There are two important parts in the resolution of program 1. The first deals with asymmetric information and it is encompassed in equation (2). Townsend(1982) showed that under the assumption of no observability/no verifiability by agent 2, ($\theta = 0$), in a model of one only period—and, hence, without any role for reputation or other dynamic mechanisms— transfers cannot depend on the revealed state. Hence, in the optimum

$$\tau(\bar{x}) = \tau(\underline{x}) = \tau(x)$$

Therefore, the consumption of agent 2 does not depend on the commercial state, $c_2(\underline{x}) = c_2(\bar{x}) = c_2(x)$—where $c_2(x)$ has been introduced to simplify the notation.

The second part relates to risk-sharing in a pure exchange economy. Thus, the efficient contract will necessarily depend on the agents risk preferences.

Making the participation constraint of agent 2 hold with equality, substituting the incentive constraints into the equations, and imposing the nonnegativity constraint on consumption of agent 2 to be nonbinding, program 1 becomes program 2. In order to simplify notation, let $E[u_1\{\tau(y), \tau(x), \tau(x)\}] = \sum_{s=y,\underline{x},\bar{x}} p(s)\, U_1\{s - \tau(s)\}$ and $E[u_2\{\tau(y), \tau(x), \tau(x)\}] = \sum_{s=y,\underline{x},\bar{x}} p(s)\, U_2\{(k2 - k)r + \tau(s)\}$.

Program 2:

$$\begin{aligned} \max_{\tau(x),\tau(y)} \quad & E[u_1\{\tau(y), \tau(x), \tau(x)\}] \\ \text{s.t.} \quad & E[u_2\{\tau(y), \tau(x), \tau(x)\}] = \overline{U}_2 \\ & \tau(y) \leq y \\ & \tau(x) \leq \underline{x} \end{aligned}$$

The solution is characterized by the intersection between the participation constraint of agent 2 holding with equality and the contract curve defined by the Kuhn Tucker conditions. In order to be feasible, this intersection has to be inside the Edgeworth box.

4.1 The Participation Constraint

From the participation constraint of agent 2 holding with equality (5), it follows that there is a functional relationship between his consumption in each state. This relationship can be defined by a function $PC : \Re_+ \rightarrow \Re_+$ mapping the consumption of agent 2 in the state y into his consumption in the other states such that (5) is satisfied: $c_2(x) = PC\{c_2(y)\}$.

$$q\, U_2\{(k2-k)r+\tau(x)\}+(1-q)\, U_2\{(k2-k)r+\tau(y)\} \equiv \overline{U}_2 \geq U_2(k2\, r) \quad (5)$$

$$q\, U_2'\{(k2-k)r+\tau(x)\}\, d\tau(x) + (1-q)\, U_2'\{(k2-k)r+\tau(y)\}\, d\tau(y) = 0$$

$$\frac{dc_2(x)}{dc_2(y)} = \frac{d\tau(x)}{d\tau(y)} = -\frac{1-q}{q}\ \frac{U_2'\{(k2-k)r+\tau(y)\}}{U_2'\{(k2-k)r+\tau(x)\}} < 0$$

It is also known that the point $(k2\, r, k2\, r)$ satisfies (5) for $\overline{U}_2 = U_2(k2\, r)$. Thus, the derivative of PC at this point is $-\frac{1-q}{q}$. If agent 2 were risk-neutral, his utility function would be linear and hence his indifference curve for this utility level would cut the border of the Edgeworth box at $(c_2(y), PC\{c_2(y)\}) = ((k2-k)r + y, (k2-k)r + \frac{k\, r-(1-q)\, y}{q})$. If agent 2 were risk-averse,[16] this intersection would occur at a point where $\tau(x) = t^{pc} > \frac{k\, r-(1-q)\, y}{q}$ with

$$t^{pc} = \left[\frac{1}{q}\left[(w+k2\, r)^{\frac{1}{\rho}} - (1-q)[w+(k2-k)r+y]^{\frac{1}{\rho}}\right]\right]^{\rho} - [w+(k2-k)r] \quad (6)$$

[16] See the utility function defined in section 4.2 for both agents 1 and 2 risk-averse.

as is depicted in figure 1.[17] In general(for all possible values of $\overline{U}_2$), the indifference curve of agent 2 will cut the Edgeworth box at some point $((k2-k)r+y,(k2-k)r+t^x)$ with

$$t^x \geq t^{pc} \tag{7}$$

From figure 1 it is clear without further analysis that a contract providing full insurance to agent $2(c_2(\bar{x}) = c_2(\underline{x}) = c_2(y))$ is not feasible as long as $y < k\,r$, which is the case for $y = 0$.

4.2 The contract curve

The contract curve for interior points is defined by

$$\frac{p\,U_1'\{\bar{x}-\tau(x)\}+(1-p)U_1'\{\underline{x}-\tau(x)\}}{U_1'\{y-\tau(y)\}} = \frac{U_2'\{(k2-k)r+\tau(x)\}}{U_2'\{(k2-k)r+\tau(y)\}} \tag{8}$$

The contract curve for corner points must satisfy the Kuhn Tucker conditions, that is, (8) with $\geq$ or $\leq$ depending on the border. These define the contract curve in general. However, a complete characterization of it requires a specification of a particular sort of utility function.

Agent 1 risk-averse and agent 2 risk-neutral

As is shown in figure 2, if agent 1 were risk-averse and agent 2 risk-neutral the *sea loan* would not be optimal, since the intersection between the contract curve and the participation constraint of agent 2 holding with equality would not occur at a point in which $\tau(y) = y$(see appendix B.1). In fact, the optimal contract would provide as much maritime

[17]Notice that transfers and agent 2'consumption are two state contingent, while agent 1' consumption is three state contingent. This is why the consumption of agent 1 has two different origins in the Edgeworth box. Notice also how the shadowed area is not contractable because transfers are not feasible($\tau(x) > \underline{x}$).

insurance as possible to agent 1 —in the case of non-safe arrival, the merchant would not only be released of his repayment obligations but would receive some positive amount ($\tau(y) < y = 0$); nonetheless, the remaining information constraints make agent 1 to undertake the commercial risk.[18]

Agent 1 risk-neutral and agent 2 risk-averse

On the other hand, if agent 1 were risk-neutral and agent 2 risk-averse, the *sea loan* would be optimal(see figure 3 and Appendix B.2) and would also be so if both agents were risk-neutral, since then any division of risk would be optimal.

Both agent 1 and 2 risk-averse

Let us now consider the most likely case in which both agents are risk-averse(see section 2 for a historical motivation) with a constant degree of relative risk-aversion. Thus, a general representation of the agent's utility functions is

$$U(c_i) = U_i(c_i) = (w + c_i)^{\frac{1}{\rho}}$$

with $\rho > 1$ and $w > 0$, for $i = 1, 2$, and with $U'(.) > 0$, $U''(.) < 0$, $U'''(.) > 0$, $R(.) > 0$, $r(.) = \underline{r} > 0$, where $R(.)$ is the coefficient of absolute risk-aversion and $\underline{r}$ is the coefficient of relative risk-aversion.

The reason why w is assume to be positive is that otherwise the utility function specified above will not satisfy the required properties. An intuitive reason why $w > 0$ is not contractable(it is different from c_i) is

[18] Let x be such that $pU_1'\{\bar{x} - \tau(x)\} + (1-p)U_1'\{\underline{x} - \tau(x)\} = U_1'\{x - \tau(x)\}$. Then, equation (8) can be expressed as $U_1'\{x - \tau(x)\} = U_1'\{y - \tau(y)\}$. An optimal contract is characterized by $\{\tau(x), \tau(y)\}$ such that $c_1(x) = c_1(y)$. Given that $y < \underline{x} < x < \bar{x}$, it will not provide constant consumption for agent 1: $c_1(\underline{x}) = \underline{x} - \tau(x) < c_1(x) = x - \tau(x) = c_1(y) = y - \tau(y) < c_1(\bar{x}) = \bar{x} - \tau(x)$, since we are in the presence of asymmetric information. Thus, the classical result of Arrow and Debreu's state contingent commodity space will not apply; consumption of agent 1 will necessarily depend on the realization of the commercial risk ($\tau(\bar{x}) = \tau(\underline{x})$).

that it is perceived as a necessary-to-live good, so that any consumption below these level would required an extremely hard and bloody enforcement system which—I assume— was not available or socially accepted in that period. Alternatively, we can think about w as publicly unknown assets or assets whose owners are publicly unknown, so that they cannot be used as collateral. This assumption is also valid for the less-developed economies of today.

Operating (8) for the above utility function provides an implicit function

$$\Phi(\tau(x), \tau(y); \lambda) = 0 \tag{9}$$

where λ represents the vector of parameters $(\theta, w, \rho, k2, k, r, q, p, y, \underline{x}, \bar{x})$, and $\tau(s)$ is the transfer in the state $s = y, \underline{x}, \bar{x}$ with $\tau(x) = \tau(\underline{x}) = \tau(\bar{x})$.[19] This function gives the contract curve for interior points. Depending on λ, the contract curve will either cuts the Edgeworth box at its northern border, at any point for which an increase in $\tau(y)$ will imply $\tau(x) = \underline{x}$ for Kuhn-Tucker conditions to be satisfied, or at its eastern one at some point where $(\tau(y), \tau(x)) = (y, t^{cc*})$ with t^{cc*} defined such that (9) is satisfied for $\tau(y) = y$ (see figure 4), that is

$$\begin{aligned} \Phi(t^{cc*}, y; \lambda) = & \frac{p\,(w+\bar{x}-t^{cc*})^{\frac{1-\rho}{\rho}} + (1-p)\,(w+\underline{x}-t^{cc*})^{\frac{1-\rho}{\rho}}}{(w+(k2-k)r+t^{cc*})^{\frac{1-\rho}{\rho}}} \\ & - \frac{w^{\frac{1-\rho}{\rho}}}{(w+(k2-k)r+y)^{\frac{1-\rho}{\rho}}} = 0 \end{aligned} \tag{10}$$

The contract curve also cuts the Edgeworth box at its western border(see appendix B.3), say at a point in which $\tau(x) = \underline{t}$.

The contract curve is thus defined by $(c_2(y), c_2(x))$ such that

$$\tau(x) \begin{cases} \in [-(k2-k)r, -(k2-k)r + \underline{t}] & \text{if } \tau(y) = -(k2-k)r \qquad \text{(west)} \\ = \min\{\tau, \underline{x}\} & \text{if } \tau(y) \in (-(k2-K)r, y] \\ \in [t^{cc}, \underline{x}] & \text{if } \tau(y) = y \qquad \text{(east)} \end{cases}$$

where τ is such that (9) holds and

[19] $\Phi(\tau(x), \tau(y); \lambda) = \frac{p\,[w+\bar{x}-\tau(x)]^{\frac{1-\rho}{\rho}} + (1-p)\,[w+\underline{x}-\tau(x)]^{\frac{1-\rho}{\rho}}}{[w+(k2-k)r+\tau(x)]^{\frac{1-\rho}{\rho}}} - \frac{[w+y-\tau(y)]^{\frac{1-\rho}{\rho}}}{[w+(k2-k)r+\tau(y)]^{\frac{1-\rho}{\rho}}} = 0.$

$$t^{cc} = \min\{t^{cc*}, \underline{x}\} \tag{11}$$

Given that (9) is an implicit function, the contract curve cannot be characterized explicitly. Nonetheless, much is known about it(see Appendix B.3 and figure 4). For instance, if $t^{cc*} \leq \underline{x}$, then $\tau < \underline{x}$ (since, as $\tau(y)$ increases, $\tau(x)$ do so in the contract curve) and the contract curve does not cut the Edgeworth Box at its northern border $c_2(x) = w + \underline{x}$. By construction, it cuts the Edgeworth box at its other relevant border(when the restriction $\tau(y) \leq y$ is binding) at $(c_2(y), c_2(x)) = (w + y, w + t^{cc})$, which fulfills (9) (see figure 1).

4.3 The efficient contract

Lemma Let t^{cc} be defined by (11), t^{cc*} by (10), t^{pc} by (6) and t^{x} such that $\overline{U}_2 = E[u_2(y, t^{x}, t^{x})]$.

If

$$t^{cc} \leq t^{pc} \leq t^{x} \leq \underline{x} \tag{12}$$

the *sea loan*, (y, t^{x}, t^{x}), will be efficient, i.e. the maximizing utility contract in the Edgeworth box. Depending on how much bargaining-power agent 2 has($\overline{U}_2$), t^{x} will take some particular value.

The final inequality of (12) simply limits the maximum value of t^{x}, because the optimal contract has to be feasible, and the second one comes from (7). In other words, parameters have to be such that $t^{cc} \leq t^{x} \leq \underline{x}$. Note that this is not imposing any restriction over the parameters that violates any previous constraint.[20]

$$t^{x} \leq \underline{x} \tag{13}$$

for the voyage to be financed, since otherwise all feasible contracts would give agent 2 less utility than the riskless asset. This implies that

[20]Restrictions about parameters have been defined throughout section 3 and 4 in these terms: $\theta = 0, \rho \geq 1, w > 0, k2 \geq k > 0, r \geq 1, q \in (0,1), p \in (0,1), \bar{x} > \underline{x} > y < k\,r, q\,[p\,\bar{x} + (1-p)\,\underline{x}] + (1-q)\,y > k\,r$.

$$\underline{x} \geq \left[\frac{1}{q}\left[(w + k2\,r)^{\frac{1}{\rho}} - (1-q)(w + (k2-k)r + y)^{\frac{1}{\rho}}\right]\right]^{\rho} -$$

$$[w + (k2-k)r](= t^{pc})$$

and

$$t^{x} - t^{cc} \geq 0$$

for the *sea loan* to be efficient. This is true if

$$t^{pc} - t^{cc} \geq 0 \tag{14}$$

Statement It can be proven that the *sea loan* is the efficient contract for certain reasonable parameters.

Table 1, in its second row, sets this parameters at historically reasonable values, for which the *sea loan* is efficient,[21] since

$$t^{cc} = 30 < t^{pc} = 33.4 < \underline{x} = 40$$

Not only is the *sea loan* efficient for these particular parameters, but it is so for a neighbourhood. Table 1 gives in its third row the values of each relevant parameter for which the *sea loan* is efficient, taking the other parameters fixed at their initial values(row 2).

table 1

θ	w	ρ	y
0	3	4	0
–	–	(2.8, 11)	–

$k2$	k	r	q	p	$\underline{x}$	$\bar{x}$
10	7	1.2	0.4	0.5	40	50
(8, 11)	(6.7, 7.5)	(1.08, 1.4)	(0.37, 0.42)	(0.01, 0.92)	(34, 47)	(40.1, 97)

[21] A program, written in Fortran, which solves program 2 is available on request.

However, these simulations are no more than an illustrative example. It has been proven that there are some reasonable parameters for which the *sea loan* emerges as the efficient contract, but would it be so for all the other combinations of reasonable parameters? With 10 parameters, of which 7 can reasonable vary, many combinations derive, and simulating is far from being a complete method. Given that historical information about parameters is vague—nothing more about whether a parameter was high or low, but without specififying a particular value—the derivatives of $t^{pc} - t^{cc}$ with respect to each parameter, if monotone, will provide more information about (14).

4.4 Comparative statics

Let $\underline{x}$ be big enough so that (13) holds,[22] that is, let parameters be such that the voyage is financed without imposing any particular kind of contract.

If (14) holds, then the *sea loan* is efficient, and figure 1 does capture the nature of this environment. If $T = t^{pc} - t^{cc*} > 0$, (14) holds— that is $t^{pc} - t^{cc} > 0$— and $t^{cc*} < \underline{x}$, since $t^{pc} < \underline{x}$ was imposed. This is likely to be when a particular parameter, λ_i, is high and $\frac{\partial T}{\partial \lambda_i} > 0$ for all its domain.

• $k2$ may be relatively low, since capital was scarce and most investors were not rich,[23] and $\frac{\partial T}{\partial k2} < 0$[24]

• r may be high since capital was scarce,[23] and $\frac{\partial T}{\partial r} > 0$[24]

• k may be high, since the requirement of capital was high,[23] and $\frac{\partial T}{\partial k} > 0$[24]

[22]There is historical evidence showing very high profits regardless of the commercial realization, i.e. a very high $\underline{x}$(see among others Cohen(1992) and de Roover(1963).

[23]See section 2.

[24]See Appendix C.

• q may be low, since long-distance maritime commerce was a risky activity,[23] and $\frac{\partial T}{\partial q} < 0$[24]

• p may be low since trading was risky,[23] and $\frac{\partial T}{\partial p} < 0$[24]

• y may be very low, $y = 0$, since no-arrival meant a complete loss,[23] and $\frac{\partial T}{\partial y} < 0$[24]

• $\bar{x}$ may be high(greater than $\underline{x}$), but not too high, since long-distance maritime commerce was very profitable regardless of the commercial outcome,[23] and $\frac{\partial T}{\partial \bar{x}} < 0$[24].

Notice that $w > 0$ has been introduced in order that the utility function $U(c_i) = (w + c_i)^{\frac{1}{\rho}}$ be well-defined for all its domain, hence its value, and its derivative, is irrelevant from a historical point of view. Neither is it the coefficient of relative risk-aversion, ρ.

Therefore, it was very likely that $T \geq 0$ so that (12) hold, and consequently the *sea loan* was the efficient contract. It should also be pointed out that the derivatives of T with respect to all the relevant parameters go in the right direction. Thus, if we find some parameters which seem reasonable but still the *sea loan* is not efficient, it is possible to make the *sea loan* efficient simply by redirecting these parameters somewhat into the direction they were expected to be in reality.

5 Informational technology improvement, $\theta = 1$

I assume $\theta = 0$ for the period before the eleventh century and, therefore, for the analysis of the *sea loan*. The Commercial Revolution of the late Middle Ages brought up a large number of innovations related with trade. In particular, the informational structure changed, permitting the investor to verify the commercial outcome to some extent.[25]

[25]For notational simplicity, I will assume that the commercial state was perfectly verifiable, i.e. $\theta = 1$ instead of $\theta \in (0, 1)$.

In other words, the commercial state became public information. This was extremely important because with a one-dimensional variable, contracts cannot rely on the revealed state(see Townsend(1982)), but exclusively on the available public information. Thus, providing new public information increased the kind of contracts to be enforceably signed, that is, it enlarged the choice(restricted) set, allowing for efficient improvements.

With the *sea loan*, the merchant undertook all the commercial risk ($\tau(\underline{x}) = \tau(\bar{x})$), which would not have been optimal since both agents were risk-averse. However, it was so because the merchant was unable to credibly commit to reveal a commercial state other than the minimum verifiable($\underline{x}$ by assumption) and, hence, transfers— $\tau(\underline{x}), \tau(\bar{x})$— could only be based on this minimum. With new public information transfers can vary between them, allowing to share the commercial risk efficiently. This new information is acting like a credible commitment to reveal the true value of the state.

5.1 Solving the model for $\theta = 1$

As with program 1 in section 4, the new efficient contract will set the expected utility of agent 2 at his reservation level, and similarly too, his nonnegativity constraint on consumption, (4), can be assumed to be nonbinding. Hence, the problem to be solved, program 2', differs from program 2 only in that the incentive-constraint ($\tau(\underline{x}) = \tau(\bar{x})$) is no longer imposed, since now the commercial states are public information.

Program 2':

$$\max_{\tau(\bar{x}),\tau(\underline{x}),\tau(y)} \quad E[u_1\{\tau(y), \tau(\underline{x}), \tau(\bar{x})\}]$$

$$\text{s.t.} \quad E[u_2\{\tau(y), \tau(\underline{x}), \tau(\bar{x})\}] = \overline{U}_2 \tag{15}$$

$$\tau(y) \leq y \tag{16}$$

$$\tau(\underline{x}) \leq \underline{x} \tag{17}$$

$$\tau(\bar{x}) \leq \bar{x} \tag{18}$$

It is natural to think that if the *sea loan* solves program 2, the *commenda* will solve program 2'. Given that both agents are risk-averse, they would optimally share the risk, i.e. their consumption levels would optimally depend on the state $s = y, \underline{x}, \bar{x}$. Thus, for any optimal level of $\tau(y)$, $\tau(y) < \tau(\underline{x}) < \tau(\bar{x})$. The reason why $\tau(y)$,$\tau(y) \leq y$, is optimally set at y is that in the *sea loan* both agents agreed on agent 2 having as less navigation risk as possible ($\tau(y) = y$) when he did not assume any commercial risk. Hence, it is expected that when agent 2 is undertaking more commercial risk, he will not assume extra navigation risk.

Lemma If the *sea loan* solves program 2, the *commenda* will solve program 2'.

Proof.

Step 1. All points of the contract curve are such that $\tau(y) < \tau(\underline{x}) < \tau(\bar{x})$.

The Kuhn-Tucker conditions for program 2' are:

$$\tau(y): \quad -(1+\lambda_1)(1-q)U'\{y-\tau(y)\} + \lambda_2(1-q)U'\{(k2-k)r+\tau(y)\} - \mu_1 = 0 \quad (19)$$
$$\tau(\underline{x}): \quad -(1+\lambda_1)q(1-p)U'\{\underline{x}-\tau(\underline{x})\} + \lambda_2 q(1-p)U'\{(k2-k)r+\tau(\underline{x})\} - \mu_2 = 0 \quad (20)$$
$$\tau(\bar{x}): \quad -(1+\lambda_1)q\,pU'\{\bar{x}-\tau(\bar{x})\} + \lambda_2 q\,pU'\{(k2-k)r+\tau(\bar{x})\} - \mu_3 = 0 \quad (21)$$

Operating (19)-(21) for $U(c_i) = (w + c_i)^{\frac{1}{\rho}}$ for i=1,2 and for interior points($\mu_1 = \mu_2 = \mu_3 = 0$), we obtain linear relationships between transfers, (22)-(23):

$$\tau(\bar{x}) = \alpha_1 + \beta_1 \tau(\underline{x}) \quad (22)$$

with $\alpha_1 = \frac{[w+(k2-k)r](\bar{x}-\underline{x})}{2w+(k2-k)r+\underline{x}} > 0$ and $\beta_1 = \frac{2w+(k2-k)r+\bar{x}}{2w+(k2-k)r+\underline{x}} > 1$, so that $\tau(\bar{x}) > \tau(\underline{x})$.

$$\tau(\underline{x}) = \alpha_2 + \beta_2 \tau(y) \quad (23)$$

with $\alpha_2 = \frac{[w+(k2-k)r](\underline{x}-y)}{2w+(k2-k)r+y} > 0$ and $\beta_2 = \frac{2w+(k2-k)r+\underline{x}}{2w+(k2-k)r+y} > 1$, so that $\tau(\underline{x}) > \tau(y)$.

For corner points, equations (22)-(23) hold with inequality. For example, if $\mu_2 = 0$ and μ_1 and μ_3 do not, $\tau(\bar{x}) = \bar{x} < \alpha_1 + \beta_1\tau(\underline{x})$ and $\tau(\underline{x}) > \alpha_2 + \beta_2\tau(y)$.

Hence, $\tau(\bar{x}) > \tau(\underline{x})$:

$$\bar{x} \geq \tau(\bar{x}) \geq min\{\bar{x}, \alpha_1 + \beta_1\tau(\underline{x})\} > \tau(\underline{x})$$

because

if $\mu_2 = \mu_3 = 0$	$\tau(\bar{x}) = \alpha_1 + \beta_1\tau(\underline{x})$
if $\mu_2 = 0$ and $\mu_3 > 0$	$\tau(\bar{x}) = \bar{x} > \underline{x} \geq \tau(\underline{x})$
if $\mu_2 > 0$ and $\mu_3 = 0$	$\tau(\bar{x}) > \alpha_1 + \beta_1\tau(\underline{x})$

and $\tau(\underline{x}) > \tau(y)$:

$$\underline{x} \geq \tau(\underline{x}) \geq min\{\underline{x}, \alpha_2 + \beta_2\tau(y)\} > \tau(y)$$

because

if $\mu_1 = \mu_2 = 0$	$\tau(\underline{x}) = \alpha 2 + \beta_2\tau(y)$
if $\mu_1 = 0$ and $\mu_2 > 0$	$\tau(\underline{x}) = \underline{x} = \underline{x} > y \geq \tau(y)$
if $\mu_1 > 0$ and $\mu_2 = 0$	$\tau(\bar{x}) > \alpha_2 + \beta_2\tau(y)$

Step 2. The efficient contract establishes $\tau(y) = y$.

Let the *sea loan* (y, t^x, t^x) be the solution of program 2, and let $(y, t^{\underline{x}}, t^{\bar{x}})$ be the solution of a restricted version of program 2' in the sense that $\tau(y) = y$ is imposed.

From the *sea loan* being efficient and $b \neq t^x$, it holds that if

$$E[u_2(t^{yo}, b, b)] \geq E[u_2(y, t^x, t^x)] = \overline{U}_2$$

then

$$E[u_1(t^{yo}, b, b)] < E[u_1(y, t^x, t^x)]$$

Assume $\tau(y) \neq y$. Then the efficient contract $\mathbf{t^o} = (t^{yo}, t^{\underline{x}o}, t^{\bar{x}o})$ is such that $t^{yo} < y$ and it is possible to write

$$t^{\underline{x}o} = \underline{a} + b$$

$$t^{\bar{x}o} = \bar{a} + b$$

with $\bar{a} \neq 0 \neq \underline{a}$, $E(a) = 0$ and $b = p\, t^{\bar{x}o} + (1-p)\, t^{\underline{x}o}$.

If $\mathbf{t^o}$ is efficient then, by definition,

$$E[u_2(t^{yo}, \underline{a} + b, \bar{a} + b)] = \overline{U}_2 = E[u_2(y, t^x, t^x)] \tag{24}$$

and

$$E[u_1(t^{yo}, \underline{a} + b, \bar{a} + b)] > E[u_1(y, t^{\underline{x}}, t^{\bar{x}})] \tag{25}$$

However, (25) is not true because

$$E[u_1(t^{yo}, \underline{a} + b, \bar{a} + b)] < E[u_1(t^{yo}, b, b)] < E[u_1(y, t^x, t^x)] < E[u_1(y, t^{\underline{x}}, t^{\bar{x}})] \tag{26}$$

where the first inequality derives from the utility function being concave and $E(a) = 0$. The second one from the *sea loan* being efficient and

$$E[u_2(y, t^x, t^x)] = \overline{U}_2 = E[u_2(t^{yo}, \underline{a} + b, \bar{a} + b)] < E[u_2(t^{yo}, b, b)]$$

where the equalities are imposed by (24) and the inequality derives from the utility function being concave and $E(a) = 0$. The third inequality of (26) holds because the *sea loan* could have been chosen—program 2 is a restricted version of program 2', and it was not because it gives less expected utility to agent 1 than the *commenda*.

Hence there is a contradiction, so that the optimal is $\tau(y) = y$. QED

6 Concluding remarks

Long-distance maritime commerce can be characterized from the times of ancient Greece to those of the late Middle Ages by being extremely risky, costly, complex and by presenting very poor and asymmetric informational flows (the merchant was the only one to perfectly verify the commercial states). Although it was heavily limited, it did exist and it was ruled by voluntary negotiation, instead of law and costume. It was performed by full-time travelling merchants who acted in their own names and assumed risk in economies where a coercive power enforced contracts based on public information. These merchants lacked capital and borrowed it from certain investors. Agents were risk-averse since they could not achieve perfect risk-pooling.

Here, I reproduce the most relevant features of an economy in which the investor was unable to distinguish between the commercial outcomes—$\theta = 0$, in a model in which the *sea loan* emerges as the efficient individually-rational contract, under certain conditions. These are satisfied if the venture was very risky, very profitable in the case of safe-arrival, and/or required a great deal of scarce capital, which were in fact the characteristics of the observed economy.

The *sea loan* provided both the capital required to undertake a long-distance voyage—the contract was signed for only one trip— and navigation insurance, to some extent. It did not, however, fully insure the merchant against a navigation disaster, in which case the transfer, $\tau(y)$, would have been negative. This was because both agents were risk-averse, so none of them would optimally undertake all the risk. In fact, the investor provided as little insurance as feasibility imposed; in other words, both the merchant and the investor would have preferred a contract with higher repayment(less insurance) in the case of a sea disaster, but this was not feasible because the merchant was already paying as much as he had, $y(=0)$. Hence, a corner solution— a *sea loan*$(\tau(y) = y)$— was established.

Neither did the *sea loan* provide commercial insurance, since it was not allowed by the informational structure: in a one-period model, with no role for reputation, transfers cannot be based on private information($\tau(\underline{x}) = \tau(\bar{x}) = \tau(x)$). And only thanks to the existence of a coercive power can they be based on public information. Thus, the provision of public information is essential for an efficient allocation of the(scarce) resources, and hence for growth: if the minimum verifiable commercial outcome($\underline{x}$ on assumption) were too small for the transfer, $\tau(x)$, to satisfy the participation constraint of agent 2, the voyage would not be financed and the capital($k2$) would be allocated on the less productive activity.

Turning to commercial insurance, a contract like that of the *commenda* would have been Pareto superior, where both the navigation and the commercial risks were shared($\tau(y) = y, \tau(\underline{x}) < \tau(\underline{x})$). I suggest that an information technology improvement($\theta = 1$) began in the eleventh century, making agent 2 able to observe and verify the realization of the commercial outcome— to a certain extent— without any private cost, and, hence, relaxing the constraint of equal transfers in the case of safe-arrival and, consequently, allowing for the *commenda*.

A Historical records

A.1 68 Demosthenes, Against Lacritus 10-13.

Androcles of Sphettus and Nausicrates of Carystus lent to Artemon and Apollodorus, both of Phaselis, 3000 drachmas in silver for a voyage from Athens to Mende or Scione, and thence to Bosporus— or if they so choose, for a voyage to the left part of the Pontus as far as the Borysthenes, and thence back to Athens, on interest at the rate of 225 drachmas on the 1000; but, if they should sail out from Pontus to Hieron after the rising of Arcturus, at 300 on the 1000, on the security of 3000 jars of wine of Mende, which shall be conveyed from Mende or Scione in the twenty-oared ship of which Hyblesius is owner. They give these goods as security, owning no money upon them to any other person, nor will they make any additional loan upon this security; and they agree to bring back to Athens in the same vessel all the goods put on board in Pontus as a return cargo; and, if the goods are brought safe to Athens, the borrowers are to pay to the lenders the money due in accordance with the agreement within twenty days after they shall have arrived at Athens, without deduction save for such jettison as the passengers shall have made by common agreement, or for money paid to enemies; but without deduction for any other loss. And they shall deliver to the lenders in their entirety the goods offered as security to be under their absolute control until such time as they shall themselves have paid the money due in accordance with the agreement. And, if they shall not pay it within the time agreed upon, it shall be lawful for the lenders to pledge the goods or even to sell them for such price as they can get; and if the proceeds fall short of the sum which the lenders should receive an accordance with the agreement, it shall be lawful for the lenders, whether severally or jointly, to collect the amount by proceeding against Artemon and Apollodorus, and against all their property whether on land or sea, wheresoever it may be, precisely as if judgement had been rendered against them and they had defaulted in payment. And if they do not enter Pontus, but remain in the Hellespont ten days after the rising of dog-star, and disembark their goods at a port where the Athenians have no right of reprisal, and from thence complete their voyage to Athens, let them pay the interest written into the contract the year before. And if the vessel in which the goods shall be conveyed suffers aught beyond repair, but the security is saved, let whatever is saved be the joint property of the lenders. And in regard to these matters nothing shall have greater effect than the agreement. Witnesses: Phormio of Piraeus, Cephisodotus of Boeotia, Heliodorus of Pitthus.

(trans. Vince)

(68 Demosthenes, *Against Lacritus 10-13* cited by Mejier and O. van Nijf (1992), p.48.)

A.2 Atto notarile veneziano relativo ad un prestito marittimo

Nel nome del Signore Dio e del Salvatore nostro Gesù Cristo. Nell'anno del Signore 1131, mese di agosto, indizione nona, rialto. Io Viviano da Molin de confinio di Santo Eustadio, con i miei eredi, poiché ho ricevuto da te Pinia, vedova di Stefano Pollani de confinio di San Mosè e mia cognata, e dai tuoi eredi, duecento libbre di denari, che mi hai dato da portare ad Arta con una nave dove come nocchiero si imbarchi Almerigo Caput in Collo, da dove in tempo con quella *mudua* (convoglio) che per prima deve giungere a Venezia, io verrò o ti trasmetterò tramite un uomo fidato, con la testimonianza di uomini fidati, duecentocinquenta libbre di denari del tuo soprascritto prestito, salvo un imprevisto ostacolo, e entro trenta giorni da che lo stesso convoglio di navi sarà approdato in Venezia, io verrò e ti pagherò il soprascritto prestito e tu devi ritenerti soddisfatta delle soprascritte duecentocinquenta libbre di denari, senza porre ostacoli; tuttavia questo prestito deve ritenersi *in periculo* fino al termine predetto, cioè fino a quando le stesse navi saranno giunte a Venezia. E se non osserverò tutte le clausole di cui sopra, allora tutto quanto *in duplo caput et prode*, con i miei eredi promettiamo di dare a te e ai tuoi eredi, togliendolo dalla terra, dalla mia casa e da tutto ciò che possiedo.
Io Viviano da Molin di mio pugno ho sottoscritto.
Io Pietro Faletro, testimone, ho sottoscritto.
Io Domenico, testimone, ho sottoscritto.
Io, Vitale Longo, testimone, ho sottoscritto.
S.T. Io, Urso presbitero e notaio ho compilato ed ho dato fede.

(R. Morozzo Della Rocca-A. Lombardo, *Documenti del commercio veneziano*, sec. XI-XIII, Vol. I, Ed. Lib. It., Torino, 1940, doc. *n* 61, p. 64 cited by Di Nero and Tagheroni(1978), p. 130.)

B Characterization of the contract curve

B.1 Agent 1 risk-averse and agent 2 risk-neutral

Agent 2 being risk-neutral implies that his utility function is linear and its first derivative a constant. Thus, the right-hand side of (8) is equal to 1, so that the contract curve for interior points is characterized, in this case, by $(c_2(y), c_2(x))$ such that

$$pU_1'\{c_1(\bar{x})\} + (1-p)U_1'\{c_1(\underline{x})\} = U_1'\{c_1(y)\} \tag{27}$$

where $c_2(y) = (k2-k)r + \tau(y)$, $c_2(x) = c_2(\underline{x}) = c_2(\bar{x}) = (k2-k)r + \tau(x)$, $c_1(\bar{x}) = \bar{x} - \tau(x)$, $c_1(\underline{x}) = \underline{x} - \tau(x)$ and $c_1(y) = y - \tau(y)$.
Operating (27) for $U_1\{c_1(s)\} = (w + c_1(s))^{\frac{1}{\rho}}$ with $\rho > 1$ provides an implicit function mapping the transfer in the state y into the (fixed)transfer in the other states($\tau(x) = \tau(\underline{x}) = \tau(\bar{x})$) for some parameters λ, $\tau(x) = \varphi(\tau(y); \lambda)$. As in subsection B.3, its derivatives can be calculated locally, with $\varphi'(\tau(y); \lambda) > 0$, that is $\varphi(\tau(y); \lambda)$ is monotonically increasing in $\tau(y)$.

Lemma The interior points of the contract curve belongs to the area between the 45 degree lines passing respectively through the origin of agent 1 when $s = \underline{x}$ and $s = \bar{x}$ in the Edgeworth box.

In order that (27) holds, $\underline{x} - \tau(x) < y - \tau(y) < \bar{x} - \tau(x)$ hence,

$$\underline{x} - y + \tau(y) < \tau(x) < \bar{x} - y + \tau(y) \tag{28}$$

where the first and third expressions are the 45 degree lines passing respectively through the origin of agent 1 when $s = \underline{x}$ and $s = \bar{x}$ in the Edgeworth box.

Lemma Some border points of the contract curve are such that $\tau(x) = \varphi(\tau(y); \lambda) = \underline{x}$. In particular for $\tau(y) = y$.

This is because $\varphi(\tau(y);\lambda)$ is monotonically increasing and $t^{x} = \varphi(y;\lambda) > \underline{x}$, from the evaluation of (28) at $\tau(y) = y$; hence, nonnegative-consumption constraints are binding and $\tau(x)$ is fixed at its maximum value $\underline{x}$.

Thus, the intersection between the contract curve and the participation constraint of agent 2 will take place at a point in which $\tau(y) \neq y$, since for $\tau(y) = y$ the value of $\tau(x)$ that makes the contract curve hold, $\underline{x}$, is greater than the value for which the participation constraint of agent 2 is satisfied with equality.

B.2 Agent 1 risk-neutral and agent 2 risk-averse

The contract curve for interior points is characterized, in this case, by $(c_2(y), c_2(x))$ such that

$$U_2'\{c_2(x)\} = U_2'\{c_2(y)\}$$

Hence, the contract curve is such that $c_2(x) = c_2(y)$ for interior points and $c_2(x) > c_2(y) = (k2 - k)r + y$ otherwise(see figure 3).

B.3 Both agent 1 and 2 risk-averse

The contract curve for interior points is characterized, in this case, by $(c_2(y),\ c_2(x))$ such that

$$\frac{pU_1'\{c_1(\bar{x})\} + (1-p)U_1'\{c_1(\underline{x})\}}{U_2'\{c_2(x)\}} = \frac{U_1'\{c_1(y)\}}{U_2'\{c_2(y)\}} \tag{29}$$

Operating (29) for

$$U(c_i) = (w + c_i)^{\frac{1}{\rho}} \quad \text{for i=1,2}$$

provides an implicit function, i.e. it implicitly, and uniquely, determines the (fixed)transfer when the ship arrives home safely, $\tau(x) \in A =$

$[(k2-k)r, \underline{x}]$, as a function of the transfer in the state y, $\tau(y) \in B = [(k2-k)r, y]$: $\tau(x) = \varphi(\tau(y); \lambda)$, where λ is a vector of parameters.

Applying the implicit function theorem, the derivatives of $\varphi(\tau(y); \lambda)$ can be locally calculated at any point $(\tau(y), \tau(x)) : \tau(x) = \varphi(\tau(y); \lambda)$ for open neighbourhoods $B' \subset B, A' \subset A$.

Note that in the interior points of the contract curve, an increase in $\tau(y)$ implies an increase in $\tau(x)$, and viceversa, that is $\varphi(\tau(y); \lambda)$ is monotonically increasing in $\tau(y)$

$$\frac{d\tau(x)}{d\tau(y)} = \varphi'(\tau(y); \lambda) = \frac{a(\tau(y))}{b(\tau(y), \tau(x))} > 0$$

where

$$a(\tau(y)) = (1-\rho)[w + y - \tau(y)]^{-2+\rho^{-1}}[w + (k2-k)r + w + y]$$

$$\begin{aligned} b(\tau(y), \tau(x)) = {} & \rho[\tau(y) + w + (k2-k)r]^{\frac{1}{\rho}} \Big[\rho[\tau(x) + w + (k2-k)r]^{1-\frac{1}{\rho}} \\ & \left[\frac{p(1-\rho)(\bar{x}-\tau(x)+w)^{-2+\rho^{-1}}}{\rho^2} + \frac{(-1+p)(-1+\rho)(\underline{x}-\tau(x)+w)^{-2+\rho^{-1}}}{\rho^2}\right] \\ & + \frac{(1-\rho^{-1})\rho[-(\frac{p(\bar{x}-\tau(x)+w)^{-1+\rho^{-1}}}{\rho}) + \frac{(-1+p)(\underline{x}-\tau(x)+w)^{-1+\rho^{-1}}}{\rho}]}{(\tau(x)+w+(k2-k)r)^{\rho^{-1}}}\Big] \end{aligned}$$

<u>Lemma</u> The efficient contract will not provide maximum insurance for either of the agents. Moreover, the contract curve belongs to the area in between.

Proof:

Let (29) be expressed as

$$\frac{pU_1'\{c_1(\bar{x})\} + (1-p)U_1'\{c_1(\underline{x})\}}{U_1'\{c_1(y)\}} = \frac{U_2'\{c_2(x)\}}{U_2'\{c_2(y)\}}$$

with $c_1(x)$ defined such that

$$U_1'\{c_1(x)\} = p\,U_1'\{c_1(\bar{x})\} + (1-p)\,U_1'\{c_1(\underline{x})\}$$

and recall that $U''(.) < 0$ for all its domain.

• Let $c_2(y) \geq c_2(x)$— and hence $\tau(y) \geq \tau(x)$— then either $c_1(y) \geq c_1(x)$, which is in contradiction with $\tau(y) \geq \tau(x)$, or agent 1 is risk-neutral or risk-lover, which is not the case. Therefore, $c_2(y) < c_2(x)$. In particular, for $\tau(y) = -(k2-k)\,r$, $\tau(x)$ takes some value $\underline{t} > -(k2-k)\,r$, and the contract curve is defined for border points such that $(c_2(y), c_2(x)) = (w, w+\tau(x))$ with $\tau(x) \leq \underline{t}$.

• Let $c_1(y) \geq c_1(x)$ [26], then either $c_2(y) \geq c_2(x)$, which is a contradiction, or agent 2 is risk-neutral or risk-lover, which is not the case. Therefore, $c_1(y) < c_1(x)$. QED

C Comparative statics

Let t^{cc*} be defined by

$$\Phi(t^{cc*}, y; \lambda) = \frac{p\,(w+\bar{x}-t^{cc*})^{\frac{1-\rho}{\rho}} + (1-p)\,(w+\underline{x}-t^{cc*})^{\frac{1-\rho}{\rho}}}{(w+(k2-k)r+t^{cc*})^{\frac{1-\rho}{\rho}}} - \frac{w^{\frac{1-\rho}{\rho}}}{(w+(k2-k)r+y)^{\frac{1-\rho}{\rho}}} = 0 \tag{30}$$

Suppose that $\overline{t^{cc*}} \in A \subset \Re$ and $\overline{\lambda} \in P \subset \Re^{10}$ satisfy (30)[27] and let $A' \subset A$ and $P' \subset P$ be open neighbourhoods of $\overline{t^{cc*}}$ and $\overline{\lambda}$ with a uniquely determined "implicit" function $t^{cc*}(y;\lambda) : P' \rightarrow A'$ such that

$$\Phi(t^{cc*}(y,\lambda), y; \lambda) = 0 \qquad \forall\, \lambda \in P' \qquad \text{and}$$

$$t^{cc*}(\overline{y}, \overline{\lambda}) = \overline{t^{cc*}}$$

Since $\Phi(.)$[28] is continuously differentiable with respect to all its

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[26] Notice that the equality implies a contract curve as the one in subsection B.1.

[27] A program, written in Fortran, that calculates the efficient contract(and also t^{cc*}) is available under request.

[28] From now onwards the functions $t^{cc*}(y,\lambda)$ and $\Phi(t^{cc*}(y,\lambda), y; \lambda)$ will be respectively written $t^{cc*}(\lambda)$ and $\Phi(t^{cc*}; \lambda)$ because y is one of the parameters represented by λ.

arguments and

$$\frac{\partial\Phi(\overline{t^{cc*}};\overline{\lambda})}{\partial t^{cc*}} = \frac{\rho-1}{\rho}\left[\frac{p\,(w+\bar{x}-t^{cc*})^{\frac{1-2\rho}{\rho}}+(1-p)\,(w+\underline{x}-t^{cc*})^{\frac{1-2\rho}{\rho}}}{(w+(k2-k)r+t^{cc*})^{\frac{1-\rho}{\rho}}}+\frac{p\,(w+\bar{x}-t^{cc*})^{\frac{1-\rho}{\rho}}+(1-p)\,(w+\underline{x}-t^{cc*})^{\frac{1-\rho}{\rho}}}{(w+(k2-k)r+t^{cc*})^{\frac{1}{\rho}}}\right] > 0(\neq 0)$$

the Implicit Function Theorem—ensures the existence of such an implicit function, $t^{cc*}(y,\lambda)$, and— gives the first-order comparative statics effects of λ on t^{cc*} at a solution:

$$\frac{dt^{cc*}(\overline{\lambda})}{d\lambda_k} = -\frac{\frac{\partial\Phi(\overline{t^{cc*}};\overline{\lambda})}{\partial\lambda_k}}{\frac{\partial\Phi(\overline{t^{cc*}};\overline{\lambda})}{\partial t^{cc*}}} \qquad \text{for k=1,...,8}$$

Hence,

$$\frac{dt^{cc*}(\overline{\lambda})}{dk2} > 0 \quad \text{because} \quad \frac{\partial\Phi(\overline{t^{cc*}};\overline{\lambda})}{\partial k2} < 0$$

,which derives from

$$\frac{\partial\Phi(\overline{t^{cc*}};\overline{\lambda})}{\partial k2} = \frac{1-\rho}{\rho}\left[\frac{w^{\frac{1-\rho}{\rho}}}{(w+(k2-k)r+y)^{\frac{1}{\rho}}}-\frac{p\,(w+\bar{x}-t^{cc*})^{\frac{1-\rho}{\rho}}+(1-p)\,(w+\underline{x}-t^{cc*})^{\frac{1-\rho}{\rho}}}{(w+(k2-k)r+t^{cc*})^{\frac{1}{\rho}}}\right]r =$$

$$= \frac{1-\rho}{\rho}\left[\frac{w^{\frac{1-\rho}{\rho}}}{(w+(k2-k)r+y)^{\frac{1}{\rho}}}-\frac{\frac{w^{\frac{1-\rho}{\rho}}\,(w+(k2-k)r+t^{cc*})^{\frac{1-\rho}{\rho}}}{(w+(k2-k)r+y)^{\frac{1-\rho}{\rho}}}}{(w+(k2-k)r+t^{cc*})^{\frac{1}{\rho}}}\right]r =$$

$$= \frac{1-\rho}{\rho}\,\frac{w^{\frac{1-\rho}{\rho}}}{(w+(k2-k)r+y)^{\frac{1-\rho}{\rho}}}\left[\frac{1}{(w+(k2-k)r+y)}-\frac{1}{(w+(k2-k)r+t^{cc*})}\right]r < 0$$

where the first and third equalities derive from simply operating and the second one from imposing $\Phi(\overline{t^{cc*}};\overline{\lambda}) = 0$(we are calculating the derivative at a solution point!). From appendix B.3 it is known that $c_2(y) = (k2-k)r + \tau(y) < (k2-k)r + \tau(x) = c_2(x)\ \forall\, \tau(y), \tau(x)$, and in particular for $\tau(y) = y$ and $\tau(x) = t^{cc*}$, that is, $y < t^{cc*}$. Thus, the last expression between brackets is positive, and $\rho > 1$ justifies the inequality.

$$\frac{dt^{cc*}(\overline{\lambda})}{dk} < 0 \quad \text{because} \quad \frac{\partial\Phi(\overline{t^{cc*}};\overline{\lambda})}{\partial k} > 0$$

,which derives from applying the same reasoning as above to

$$\frac{\partial\Phi(\overline{t^{cc*}};\overline{\lambda})}{\partial k} = -\frac{1-\rho}{\rho}\frac{w^{\frac{1-\rho}{\rho}}}{(w+(k2-k)r+y)^{\frac{1-\rho}{\rho}}}\left[\frac{1}{(w+(k2-k)r+y)} - \frac{1}{(w+(k2-k)r+t^{cc*})}\right] r > 0$$

$$\frac{dt^{cc*}(\overline{\lambda})}{dr} > 0 \quad \text{because} \quad \frac{\partial\Phi(\overline{t^{cc*}};\overline{\lambda})}{\partial r} < 0$$

,which derives from applying the same reasoning as above to

$$\frac{\partial\Phi(\overline{t^{cc*}};\overline{\lambda})}{\partial r} = \frac{1-\rho}{\rho}\frac{w^{\frac{1-\rho}{\rho}}}{(w+(k2-k)r+y)^{\frac{1-\rho}{\rho}}}\left[\frac{1}{(w+(k2-k)r+y)} - \frac{1}{(w+(k2-k)r+t^{cc*})}\right] (k2-k) < 0$$

$$\frac{dt^{cc*}(\overline{\lambda})}{dq} = 0$$

$$\frac{dt^{cc*}(\overline{\lambda})}{dp} > 0 \quad \text{since} \quad \frac{\partial\Phi(\overline{t^{cc*}};\overline{\lambda})}{\partial p} = \frac{(w+\bar{x}-t^{cc*})^{\frac{1-\rho}{\rho}} - (w+\underline{x}-t^{cc*})^{\frac{1-\rho}{\rho}}}{(w+(k2-k)r+t^{cc*})^{\frac{1-\rho}{\rho}}} < 0$$

$$\frac{dt^{cc*}(\overline{\lambda})}{dy} > 0 \quad \text{since} \quad \frac{\partial\Phi(\overline{t^{cc*}};\overline{\lambda})}{\partial y} = \frac{1-\rho}{\rho}\frac{w^{\frac{1-\rho}{\rho}}}{(w+(k2-k)r+y)^{\frac{1}{\rho}}} < 0$$

$$\frac{dt^{cc*}(\overline{\lambda})}{d\underline{x}} > 0 \quad \text{since} \quad \frac{\partial\Phi(\overline{t^{cc*}};\overline{\lambda})}{\partial \underline{x}} = (1-p)\,\frac{1-\rho}{\rho}\,(w+\underline{x}-t^{cc*})^{\frac{1-2\rho}{\rho}} < 0$$

$$\frac{dt^{cc*}(\overline{\lambda})}{d\bar{x}} > 0 \quad \text{since} \quad \frac{\partial\Phi(\overline{t^{cc*}};\overline{\lambda})}{\partial \bar{x}} = p\,\frac{1-\rho}{\rho}\,(w+\bar{x}-t^{cc*})^{\frac{1-2\rho}{\rho}} < 0$$

Let t^{pc} be defined by

$$t^{pc} = \left[\frac{1}{q}\left[(w+k2\,r)^{\frac{1}{\rho}} - (1-q)(w+(k2-k)r+y)^{\frac{1}{\rho}}\right]\right]^{\rho} - [w+(k2-k)r]$$

Hence,

$$\frac{\partial t^{pc}}{\partial k2} = \; -r + \left[\frac{1}{q}\left[(w+k2\,r)^{\frac{1}{\rho}} - (1-q)(w+(k2-k)r+y)^{\frac{1}{\rho}}\right]\right]^{\rho-1}$$

$$\frac{r}{q}\left[(w+k2\,r)^{\frac{1-\rho}{\rho}} - (w+(k2-k)r+y)^{\frac{1-\rho}{\rho}}\right] < 0$$

because $\rho > 1$, $q \in (0,1)$ and $y < k\,r$, hence $(w+k2\,r)^{\frac{1}{\rho}} > (w+(k2-k)r+y)^{\frac{1}{\rho}} > (1-q)\,(w+(k2-k)r+y)^{\frac{1}{\rho}}$ and $(w+k2\,r)^{\frac{1-\rho}{\rho}} < (w+(k2-k)r+y)^{\frac{1-\rho}{\rho}}$.

$$\frac{\partial t^{pc}}{\partial k} = \; r + \left[\frac{1}{q}\left[(w+k2\,r)^{\frac{1}{\rho}} - (1-q)(w+(k2-k)r+y)^{\frac{1}{\rho}}\right]\right]^{\rho-1}$$

$$\frac{(1-q)r}{q}\,(w+(k2-k)r+y)^{\frac{1-\rho}{\rho}} > 0$$

since $\rho > 1$, $q \in (0,1)$ and $y < k\,r$.

$$\frac{\partial t^{pc}}{\partial r} = \; -(k2-k) +$$

$$\left[\frac{1}{q}\left[(w+k2\,r)^{\frac{1}{\rho}} - (1-q)[w+(k2-k)r+y]^{\frac{1}{\rho}}\right]\right]^{\rho-1}\frac{1}{q}$$

$$\left[k2(w+k2r)^{\frac{1-\rho}{\rho}} - (1-q)(k2-k)[w+(k2-k)r+y]^{\frac{1-\rho}{\rho}}\right]$$

which is positive sometimes and negative other times.

$$\frac{\partial t^{pc}}{\partial q} = \; \rho\left[\frac{1}{q}\left[(w+k2\,r)^{\frac{1}{\rho}} - (1-q)(w+(k2-k)r+y)^{\frac{1}{\rho}}\right]\right]^{\rho-1}$$

$$\frac{(w+(k2-k)r+y)^{\frac{1}{\rho}} - (w+k2\,r)^{\frac{1}{\rho}}}{q^2} < 0$$

because $\rho > 1$, $q \in (0,1)$ and $y < k\,r$, hence $(w+k2\,r)^{\frac{1}{\rho}} > (w+(k2-k)r+y)^{\frac{1}{\rho}} > (1-q)\,(w+(k2-k)r+y)^{\frac{1}{\rho}}$.

$$\frac{\partial t^{pc}}{\partial p} = 0$$

$$\frac{\partial t^{pc}}{\partial y} = - \left[\frac{1}{q}\left[(w + k2\,r)^{\frac{1}{\rho}} - (1-q)(w + (k2-k)r + y)^{\frac{1}{\rho}}\right]\right]^{\rho-1}$$

$$\frac{1-q}{q}\,(w + (k2-k)r + y)^{\frac{1-\rho}{\rho}} < 0$$

because $\rho > 1$, $q \in (0,1)$ and $y < k\,r$, hence $(w + k2\,r)^{\frac{1}{\rho}} > (w + (k2-k)r + y)^{\frac{1}{\rho}} > (1-q)\,(w + (k2-k)r + y)^{\frac{1}{\rho}}$.

$$\frac{\partial t^{pc}}{\partial \underline{x}} = 0$$

$$\frac{\partial t^{pc}}{\partial \bar{x}} = 0$$

In conclusion,

$$\frac{\partial T}{\partial k2} = \frac{\partial t^{pc}}{\partial k2} - \frac{\partial t^{cc*}}{\partial k2} < 0$$

$$\frac{\partial T}{\partial k} = \frac{\partial t^{pc}}{\partial K} - \frac{\partial t^{cc*}}{\partial k} > 0$$

$$\frac{\partial T}{\partial q} = \frac{\partial t^{pc}}{\partial q} - \frac{\partial t^{cc*}}{\partial q} < 0$$

$$\frac{\partial T}{\partial p} = \frac{\partial t^{pc}}{\partial p} - \frac{\partial t^{cc*}}{\partial p} < 0$$

$$\frac{\partial T}{\partial y} = \frac{\partial t^{pc}}{\partial y} - \frac{\partial t^{cc*}}{\partial y} < 0$$

$$\frac{\partial T}{\partial \underline{x}} = \frac{\partial t^{pc}}{\partial \underline{x}} - \frac{\partial t^{cc*}}{\partial \underline{x}} < 0$$

$$\frac{\partial T}{\partial \bar{x}} = \frac{\partial t^{pc}}{\partial \bar{x}} - \frac{\partial t^{cc*}}{\partial \bar{x}} < 0$$

The evaluation of

$$\frac{\partial T}{\partial r} = \frac{\partial t^{pc}}{\partial r} - \frac{\partial t^{cc*}}{\partial r}$$

is highly untreatable. For all the running simulation it was positive.

References

[1] Aragio-Ruiz, V. 1991. "Instituzioni di Diritto Romano." **Editrice Dottore Eugenio Jovene**, 300-307.

[2] Banerjee, A.V., T. Besley and T.W. Guinnane. 1994. "Thy Neighbor's Keeper: The Design of a Credit Cooperative with Theory and Test." *Quarterly Journal of Economics* **109**, 491-515.

[3] Birdzell, L.E. Jr. and N. Rosenberg. 1986. "How the West Grew Rich. The Economic Transformation of the Industrial World". **Basic Books Inc.**.

[4] Cheung, C. 1969. "Transaction Cost, Risk-Aversion and the Choice of Contractual Arrengements". Chapter 22 in Diamond P. and M. Rothschield. 1989. "Uncertainty in Economics: Readings and Exercises." **Academic Press, Inc.**

[5] Cipolla, C.M. 1960. "Appunti per una Nuova Storia della Moneta nell'Alto Medioevo" in "Moneta e scambi nell'Alto Medioevo". Settimana di studio del centro Italiano di studio sull'Alto Medioevo.

[6] Cipolla, C.M. 1980. "Before the Industrial Revolution". **Norton.**

[7] Coase, R.H. 1937. "The Nature of the Firm". *Econometrica* **4**, 386-405.

[8] Cohen E.E. 1992. "Athenian Economy and Society: a Banking Perspective". **Princeton UP**.

[9] De Roover, R. 1963 . " The Organization of Trade". **Cambridge Economic History of Europe**, Vol. 3, 42-118.

[10] Di Nero, L. and M. Tangheroni. 1978. "Commercio e Navigazione nel Mediterraneo Medioevale". **Scholastica**

[11] Fama, E.F. and M.C. Jensen. 1983a. "Separation of Ownership and Control". *Journal of Law and Economics* **26**, 301-326.

[12] Fama, E.F. and M.C. Jensen. 1983b. "Agency Problems and Residual Claims". *Journal of Law and Economics* **26**, 327-349.

[13] Gale, D. and M, Hellwig. 1985. "Incentive-Compatible Debt Contracts: The One Period Problem." *Review of Economic Studies* **52**, 647-663.

[14] Green, E. and S.N. Oh. 1991. " Can a "Credit Crunch" Be Efficient." *Quarterly Review of the Federal Reserve Bank of Minneapolis* **58**, 3-17.

[15] Greif, A. 1989. "Non-Market Economic Institutions in Medieval Trade: Evidence from the Genezia Documents." Manuscript. Northwestern University.

[16] Greif, A. 1992a. "Institutional Infrastructure and Economic Development: Reflection from the Commercial Revolution." Standford University.

[17] Greif, A. 1992b. "Cultural Beleifs and the Organization of Society: A Historical and Theoretical Reflection on Collectivist and Individualist Societies". Memorandum. Standford University.

[18] Greenwald, B.C. and J.E. Stiglitz. 1991. " Information, Finance and Markets: the Architecture of Allocative Mechanisms". *NBER* WP 652.

[19] Hart, O. and J. Moore. 1988. "Property Rights and the Nature of the Firm". *London School of Economics*. Discussion Paper.

[20] Holmstrom, B. 1979. "Moral Hazard and Observability". *Bell Journal of Economics* **10**, 74-91.

[21] Jorgan, W. 1988. "Women and Credit in the middle Ages: problems and directions". *Journal of European Economic History* **17(1)**, 33-62.

[22] Lane, F.C. 1944. "Family Partnership and Joint Ventures in Venetian Republic". *Journal of Economic History* **4**, 178-196.

[23] Lane, F.C. 1973. "Venice. A Maritime Repubic". **The Johns Hopkins University Press**.

[24] Lane, F.C. 1987. "Studies in Venetian Social and Economic History". **Variorum reprints**. Chapters 1, 2 and 7.

[25] Leone, A. 1983. "Maritime Insurance as a Source for the History of International Credit in the Middle Ages." *Journal of European Economic History* **12(2)**, 363-69.

[26] Lopez, R. 1943. "European Merchants in the Medieval Indies: The Evidence of Commercial Documents," *Journal of Economic History* **Vol 3**,164-84

[27] Lopez, R. S. 1960."Moneta e Monetieri nell'Italia Barbarica" in "Moneta e scambi nell'Alto Medioevo". Settimana di studio del centro Italiano di studio sull'Alto Medioevo.

[28] Lopez, R. 1976. "The Commercial Revolution of the Middle Ages, 959-1350". **Cambridge: Cambridge University press**.

[29] Lopez, R. 1979. "The Dawn of Medieval Banking" in "The Dawn of Modern Banking". 1979. Center for Medieval and Renaissance Studies.**UCLA** New Haven and London U.P.

[30] Luzzatto, G. 1943. "La commenda nella Vita Economica dei Secoli XIII e XIV, con particolare risguardo a venezia" in "Atti della Mostra Bibliografica e Convegno Internazionale di Studi Storici dell Diritto Maritimo Medioevale" Amalfi, luglio e ottobre 1934. Napoli 1943. I, 139-164.

[31] Luzzatto, G. 1954. "Studi di Storia Economica Veneziana". **Cedam**.

[32] Luzzatto, G. 1960. "Economia Naturale ed Economia Monetaria nell'Alto Medioevo" in "Moneta e scambi nell'Alto Medioevo". Settimana di studio del centro Italiano di studio sull'Alto Medioevo.

[33] Luzzatto, G. 1961. "Storia Economica di Venezia dall'XI all'XVI secolo". Centro internazionale delle arti e del costume.

[34] Luzzattoo, G. "Breve Storia economica dell'Italia Medievale".

[35] Mas-Colell A., M.D. Winston and J.R. Green. 1995. "Microeconomic Theory" **Oxford University Press.**

[36] Morozzo della Rocca, R. 1940. "Documenti del Commercio Veneziano, se. XI-XIII. Vol. I.**Ed. Lit. It.**.

[37] Marimon, R. 1991. "Mercados e Instituciones para el Intercambio." Chapter 1 in Marimon, R. y X. Calsamiglia Directores. 1991. "Invitacion a la Teoría Economica." **Ariel.**

[38] Mejier and O. van Nijf. 1992. "Trade, Transport and Society in the Ancient World". **A Source Book**

[39] Milgrom, P.R., D.C. North and B.R. Weingast. 1990. "The role of Institutions in the revival of Trade: The Law Merchant, Private Judges and the Champagne Fairs." *Economics & Politics* **Vol. 2**, 1-23.

[40] North, D.C. and R.P. Thomas. 1973. "The rise of the Western World". **Cambridge University Press.**

[41] North, D.C. 1990. "Institutions, Institutional Change and Economic Performance". **Cambridge University Press.**

[42] Pratt, J.W. 1964. " Risk-Aversion in the Small and in the Large". Chapter 4 in Diamond P. and M Rothschield. 1989. "Uncertainty in Economics: Readings and Exercises." **Academic Press, Inc.**

[43] Pryor, J.H. 1984. "Commenda: The Operation of the Contract in Long- Distance Commerce." *Journal of European Economic History***13(1)**, 397-440.

[44] Rothenberg, T.J. and K.R. Smith. 1971. "The Effect of Uncertainty on Resource Allocation". Chapter 10 in Diamond P. and M Rothschield. 1989. "Uncertainty in Economics: Readings and Exercises." **Academic Press, Inc.**

[45] Townsend, R. M. 1978. "Optimal Contracts and Competitive Markets with Costly State Verification". *Journal of Economic Theory* **21**, 417-425.

[46] Townsend, R. M. 1982. "Optimal Multiperiod Contracts and the Gain from Enduring Relationships under Private Information." *Journal of Political Economy* **90(6)**, 116-186.

[47] Townsend, R. M. 1990a. "Key Elements and Patterns in Theory and Early European History". Chapter 1 in Townsend, R. M. 1990. "Financial Structure and Economic Organization". **Blackwell**.

[48] Townsend, R.M. 1994. "Risk and Insurance in Village India." *Econometrica* **62**, 539-591.

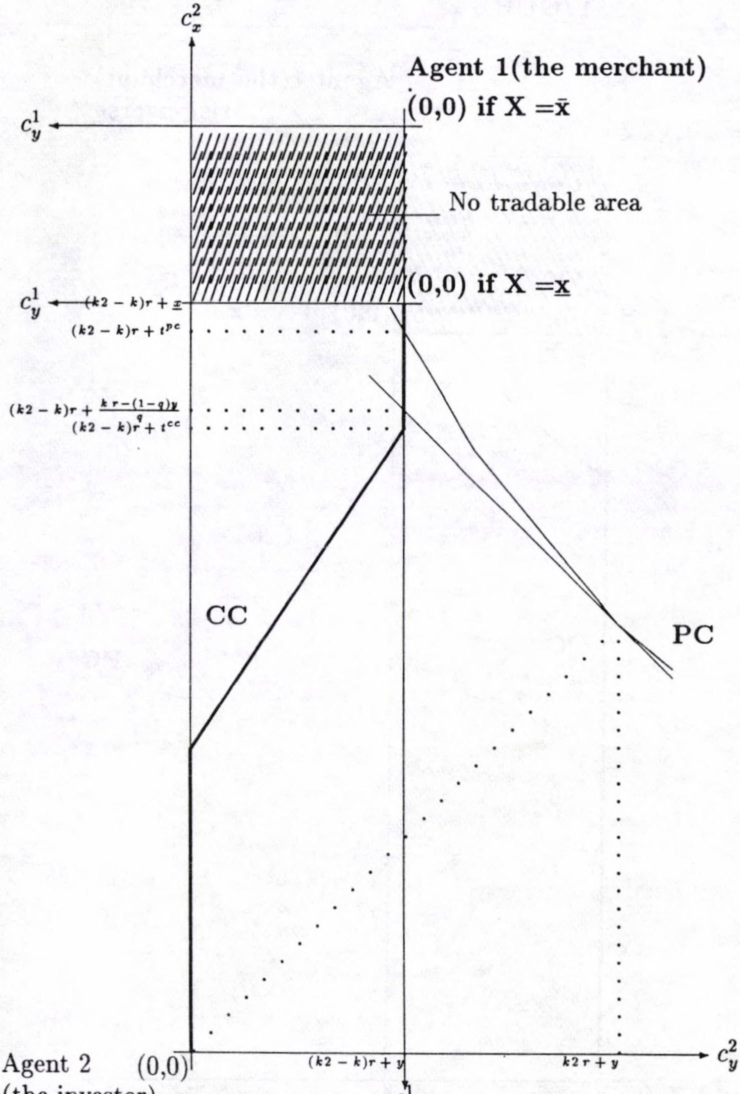
[49] Udovitch, A.L. 1979. "Bankers without Banks". Commerce, Banking and Society in the Islamic World of the Middle Ages" in "The Dawn of Modern Banking". 1979. Center for Medieval and Renaissance Studies.**UCLA** New Haven and London U.P.

[50] Varian, H.R. 1992. "Microeconomic Analysis." **Norton.** Third Edition. Chapter 11.

[51] Yarbrough, B.V. and R.M. Yarbrough. 1988. " The Transactional Structure of the Firm". *Journal of Economic Behavior and Organization* **10**, 1-28.

[52] Zou, L. 1992. "Ownership Structure and Efficiency: An Incentive Mechanism Approach".*Journal of Comparative Economics* **16**, 399-431.

FIGURE 1



c_x^2
Agent 1(the merchant)
(0,0) if X =x̄
c_y^1
No tradable area
(0,0) if X =x̲
c_y^1
$(k2-k)r+\underline{x}$
$(k2-k)r+t^{pc}$
$(k2-k)r+\frac{k\,r-(1-q)y}{q}$
$(k2-k)r+t^{cc}$
CC
PC
Agent 2
(the investor)
(0,0)
$(k2-k)r+y$
$k2\,r+y$
c_y^2
c_x^1

FIGURE 2

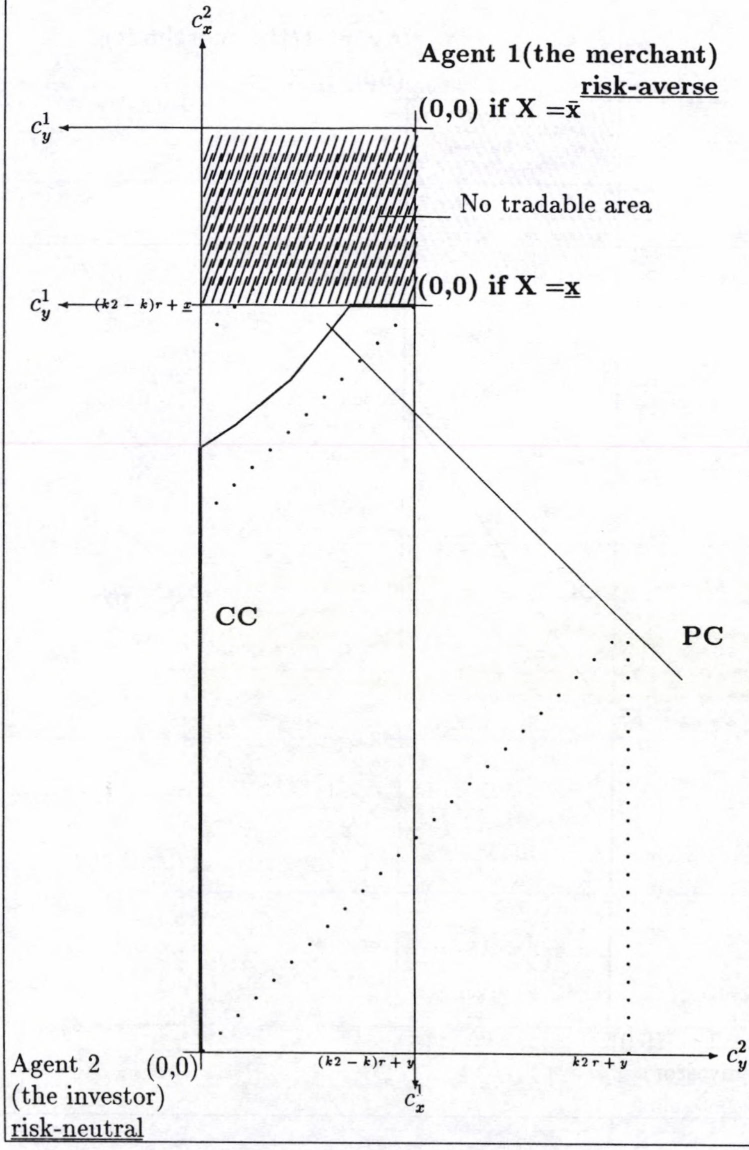
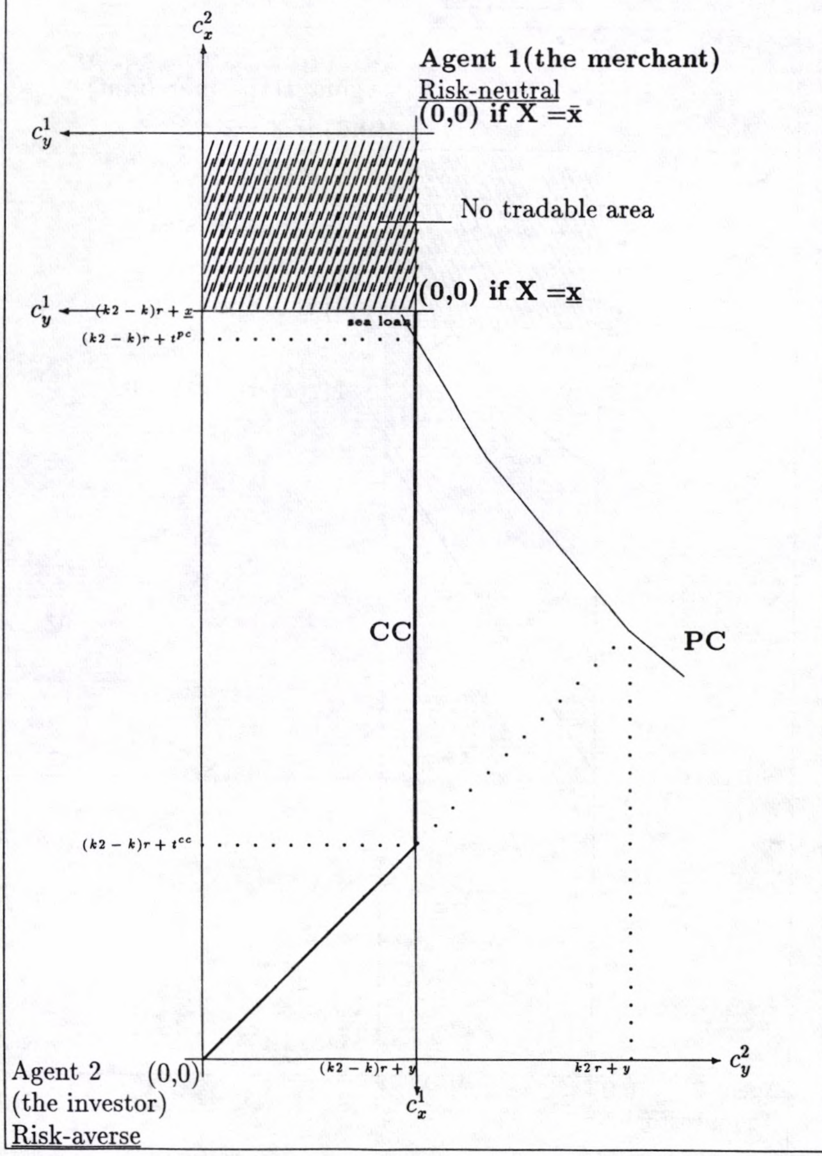
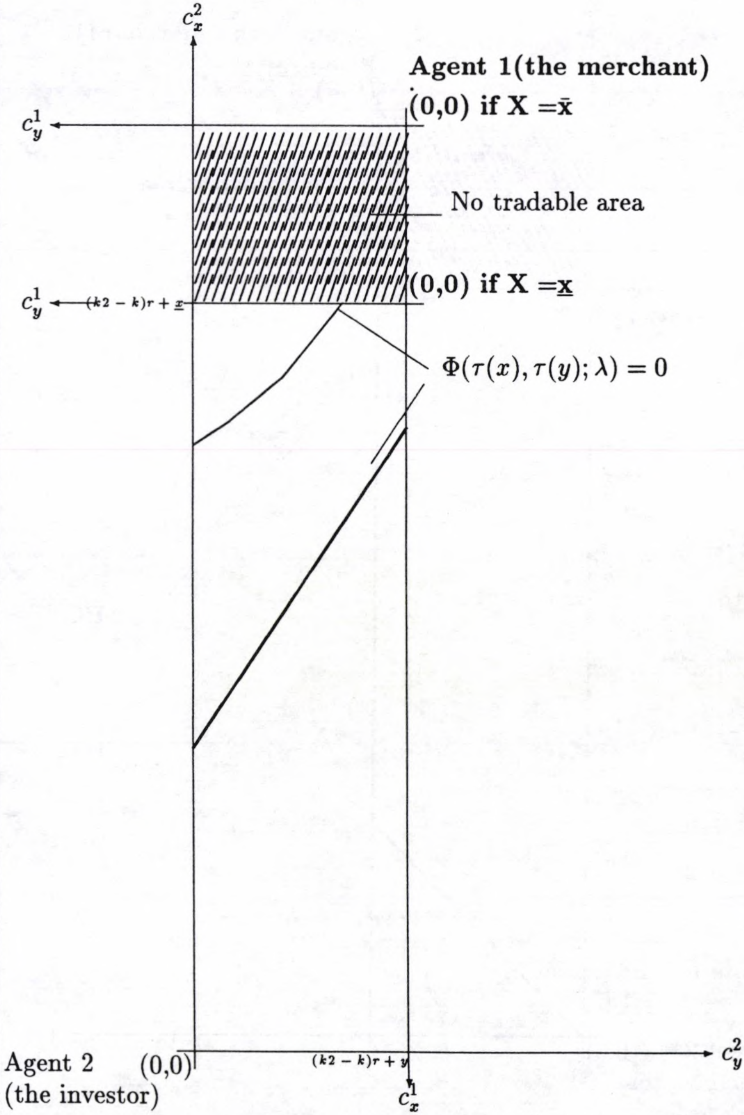

c_x^2
Agent 1(the merchant)
risk-averse
(0,0) if X =$\bar{x}$
c_y^1
No tradable area
(0,0) if X =$\underline{x}$
c_y^1
$(k2-k)r+\underline{x}$
CC
PC
Agent 2
(the investor)
risk-neutral
(0,0)
$(k2-k)r+y$
$k2\,r+y$
c_y^2
c_x^1

FIGURE 3



c_x^2
Agent 1(the merchant)
Risk-neutral
(0,0) if X =x̄
c_y^1
No tradable area
(0,0) if X =x̲
c_y^1
$(k2-k)r+\underline{x}$
sea loan
$(k2-k)r+t^{pc}$
CC
PC
$(k2-k)r+t^{cc}$
Agent 2
(the investor)
Risk-averse
(0,0)
$(k2-k)r+y$
$k2\,r+y$
c_y^2
c_x^1

FIGURE 4


c_x^2
Agent 1(the merchant)
(0,0) if X = x̄
c_y^1
No tradable area
(0,0) if X = x
c_y^1
$(k2-k)r+\underline{x}$
$\Phi(\tau(x), \tau(y); \lambda) = 0$
Agent 2
(the investor)
(0,0)
$(k2-k)r+y$
c_y^2
c_x^1

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