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Gambling on Claim Frequency: Loss Expectation and the Spread of Risks in the Making of Modern Insurance

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Abstract: In this paper, I argue that the two main principles underlying modern insurance business, i. e., loss expectation and the spread of risks, were not unknown in late-medieval and early-modern insurance practice. The former was embedded into premium rates and explains why in late-medieval and early-modern insurance contracts, premiums were expressed not as a bare sum but in the form of a rate. The latter was clearly formulated by Benedetto Cotrugli as he recommended to underwrite "continuously, & upon every ship, because the one offsets the other, & by pooling, [insurers] cannot but make a profit". I focus on the principle of loss expectation and argue that underlying this principle there was a kind of commodification of uncertainty that both propelled and was supported by the semantic distinction of risk and danger. I finally sketch out some of the reasons why the basic principles underlying insurance business could find full exploitation only in modern society, and argue that if a statistical calculus of probability for insurance purposes was first carried out between the mid-17th century and the mid-18th century, it was not because of a deficit of ideas but because of a deficit of social structures. Compared to modern insurance business, late-medieval and early-modern insurance agreements were, in the end, a form of gambling based on some estimate of claim frequency.

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1 Introduction

The origin of insurance contracts is undoubtedly one of the most intriguing topics of both the history of law and the history of economy dealing with the transition from late-medieval to early-modern society. The same topic is also crucial for historical sociology simply because insurance is a core institution of modern society. A history of insurance in a global perspective should be, therefore, an interdisciplinary endeavour. A sociology of insurance, on the other hand, is not yet available.[1] This is all the more surprising if one takes into account its close link with the sociology of risk – a discipline which has already been extensively developed (Beck 1986; Luhmann 1991).

To fill this gap, a sociological theory of insurance decision-making should first be developed.[2] An in-depth investigation into the interplay between insurance and social structures in modern society should then be carried out. Finally, the complex relationship between insurance and prevention should be explored even in the light of recent developments in algorithmic prediction techniques based on behavioural data for usage-based insurance policies.

Compared to this research agenda, the purpose of this article is much more modest, but not without connections. Starting with a very specific issue, namely the determination of insurance premiums in the form of tariffs in late-medieval maritime insurance contracts, I would like to show that a socio-evolutionary approach can re-interpret historical sources to understand the emerging of early-modern risk society.

The reason that makes the origins of insurance contracts such an intriguing topic is that, although historical research has produced a vast amount of knowledge about the technical and legal requirements of these contracts, many aspects of their underlying mechanism still remain unclear.[3] Consider, for example, the following maritime insurance policy taken out in the second half of the 14th century:

In 1385 Francesco di Marco da Prato & Co. arranges insurance with three merchants on a cargo worth 400 florins sailing from Arles up to Porto Pisano. The premium rate to be paid is 5 % (of the cargo value). Michele del Voglia & Co. promise to pay compensation for 150 florins, Bartolomeo and Piero del Voglia agree to pay compensation for 150 florins, Michele di Carlo degli Strozzi promises

1 Twenty years ago, according to Ericson et al. (2003, 3), a sociology of insurance was still "nascent". Over the last twenty years, the situation does not seem to have changed very much.

2 Preparatory research can be found in Tönnies (1917) and Luhmann (1996).

3 Edler de Roover (1945, 172) stated that the origins of insurance represent "one of the most complicated and controversial question in the history of business institutions".

to pay 100 florins. The total amount of premium to be paid in advance is 20 florins, which implies a profit of 7.50 florins for the first two co-insurers and a profit of 5.00 florins for the latter (Bensa 1884, 210–212).

Maritime insurance contracts taken out between the mid-14th century and the first half of the 16th century all have a similar form (Bensa 1884; Brunetti 1936; Checchini 1958; Daveggia 1967; Nelli 1972). The extensive historical research that explored these contracts pointed out that the main features of these agreements were as follows:

1. The contract enacts a *bilateral risk*.[4] The insurer assumes the risk of indemnifying a contingent loss only if the insured runs the risk of paying the premium without receiving any financial benefit in return. This aspect is extensively discussed in early-modern legal and moral-economic literature under the concept of "risk assumption" (susceptio periculi).
2. Insurers almost never expose themselves for the full amount of the claim. They expose themselves pro quota. The prevailing mechanism is therefore *risk sharing*.
3. Insurers very often are *non-specialised* investors who use insurance as an opportunity to diversify their speculative investments.
4. Insurance agreements use a semantics of risk that distinguishes damages imputable to an external cause (peril) from damages imputable to an internal cause (risk). The usual expression is "ad risicum et periculum". Into this semantics of risks and perils is embedded the neologism 'a(s)sichurare' (to insure), 'fare' and 'pigliare sichurtà' (to sell and take out insurance), with many variants in vernacular languages.
5. The premium is not calculated as a net amount but as a *rate* referring to the total amount of future compensation. The latter usually coincides with the total value of the insured cargo. In late-medieval and early-modern insurance agreements, rates are always set in percentage form.

Historical research has extensively investigated the structure of insurance rates in early maritime insurance contracts, focusing on certain markets and historical periods. The gaps in the available sources and the fragmentation of research unfortunately make it difficult to gain an overview, so much work remains to be done.[5] In this article, I first deal with a specific question: Why is the policy

4 According to Soto (1582, 207r), it is fair to pay a premium because both parties (of an insurance contract) expose themselves to a danger.

5 See Del Treppo (1957; 1958); Heers (1959); Doehaerd (1949); Melis (1975); Nehlsen-von Stryk (1981; 1988); A. Tenenti (1985; 1987); B. Tenenti (1985); Tenenti/Tenenti (1978; 1985); Ceccarelli (2007; 2010; 2012). This literature is, of course, not comprehensive.

premium expressed not as a bare sum but in the form of a rate? To the best of my knowledge, this question has never been asked in such a focused way.[6]

The issue of pre-modern insurance rate-making is, indeed, rather enigmatic. Historical research has unequivocally shown that these rates were not set arbitrarily or, even worse, at will. Rate-making shows, instead, "internal consistency", as Alberto Tenenti (1987, 347) pointed out, even if it is not entirely clear what the underlying rationale was (cf. also Nehlsen-von Stryk 1989, 202). On the other hand, it is well known that in the late Middle Ages there were no established mathematical techniques for the statistical-probabilistic calculation of insurance rates. However, everything suggests that these rates were precisely the result of a calculation.

Following a suggestion by Niklas Luhmann (1996, 279), in this article I try to give a contribution to a sociological exploration of early-modern insurance as a particular instance of socio-cultural evolution. The first hypothesis I explore is that premium rates basically coincide with the estimated claim frequency (section 2). This hypothesis could explain why insurance rates vary over time and according to circumstances, as the past that has to be taken into consideration in the present is continuously different, and why, despite these variations, insurance rates show a striking regularity, as their making is precisely the result of a calculation. Starting from this hypothesis, it is possible to draw the conclusion that the premium-setting approach of late-medieval insurers was a proto-statistical and proto-probabilistic approach.

After a brief investigation of the functional differentiation of risk-taking as an evolutionary advance (section 3), in the fourth section I explore the relationship of late medieval merchants with uncertainty. Starting from the counter-concepts risk and danger which are commonly used in maritime insurance contracts, I show that the evolutionary novelty introduced by insurance consists in internalising uncertainty, i. e., in making uncertainty something available and precisely for this reason quantifiable. In this way, an uncontrollable fortune is transformed into a calculated risk, and this on the side of both the insurer and the insured.

In the fifth section, I explain how this quantification was performed and argue that late-medieval insurance mostly was, despite everything, a form gambling. The reason why it mostly was a form of gambling is not so much because of the incapability of merchants to mathematically calculate the outcomes of chance, but rather because of their impossibility of distributing losses over a large pool of policyholders.

6 I pointed it out in Cevolini 2016.

This principle of pooling and spreading risks was not unknown to early-modern insurers, but it was implemented systematically only between the 18th and 19th centuries. Sociological theory of modern society suggests that this happened due to the transformations of social structures brought about by functional differentiation, rather than simply as a result of the development of statistical-probabilistic calculation. In this article, I suggest that a crucial evolutionary change is the exemption of interaction systems and medieval mutual-help associations from their providence function. The latter is assigned to social subsystems (economy and politics) which implement it through their own organisations. However, this is a very complex sociological issue that deserves larger investigation.

In the sixth section, I therefore focus on some consequences of aleatory contracts on the idea of probability underlying insurance mathematical calculus. My hypothesis is that, to establish itself, this calculus had to cross several plausibility thresholds, and that its contribution to the establishment of modern insurance industry mainly consisted in providing the crucial idea that there is an order in contingency, and that insurers can bet on it.

2 Estimates without probability

On the basis of a thorough historical investigation, Giovanni Ceccarelli has argued that those of the late-medieval and early-modern insurers were, so to speak, "estimates without [a calculus of] probability" (Ceccarelli 2010). The interesting aspect of this clever formulation is that it practically is an oxymoron: to estimate the uncertainty of a future event one needs to get an idea of the likelihood (or, unlikelihood) of its occurrence. Ceccarelli (2007; 2010; 2012) distinguishes, in this respect, structural risk factors (e. g., vessel, reputation, trip, season) from contingent risk factors (e. g., pirates, war). Yet, in my opinion this distinction is misleading because future events are always contingent, that is, unpredictable. The matter rather is how to assess risks.

On one hand, the perception of risk depends on information. But it is also true that the search for information depends on risks to which decision-makers expose themselves. Merchants were well aware that they were exposing their cargos to the "risk of sea and people", as it is commonly said in late-medieval maritime insurance contracts. From this risk, insurers were driven to explore those aspects of reality about which it was appropriate to produce information. In very abstract terms, the matter was to compensate the uncontrollability of the environment through a self-produced uncertainty (Luhmann 1993, 310). This, of course, created self-deception possibilities: one spent a lot of money on insurance for fear of a

disaster, everything went smoothly, the insured had to admit that his fears were unfounded. The insured, however, could only know it ex post, consequently ex ante it was advisable to run the risk of insurance.

Every risk implies, moreover, a selection of relevant environment. This selection selects information the decision-maker is searching for. Because complete information is impossible, the decision-maker is dealing with both certainty and uncertainty. Uncertainty as well as certainty refer to the environment but are produced by the system.[7] Information thus affects the perception of risk, but risk in turn structures the search for information. An investigation of pre-modern insurance rate-making should, therefore, start from the assumption that late-medieval insurers were dealing with a *self-produced uncertainty*.

Assuming, then, that risk assessment took into account a variety of factors, it is unclear how these factors were "synthesised" (Ceccarelli 2012, 153) in one and the same rate. To say that insurance rates were a sort of "symbolic numerical transposition" (Ceccarelli 2007, 18; cf. also Ceccarelli 2010, 677) of the uncertain conditions under which insurance agreements were underwritten leaves open the question of how this transposition was practically implemented and eventually accepted by the parties involved in the agreement.

The main hypothesis remains that premium rates were a "combination" and "measure" of various risk assessments, as Balthazard Marie Émérigon (1850 [1783], 13) pointed out. Underlying these operations there should be some rational reasoning and calculus that made insurance business somehow consistent. Aleatory contracts, in short, could not be underwritten haphazardly.

That the risk could be quantified and thus receive a price, after all, was already admitted in Roman law; it had to some extent been theorised in the late Middle Ages; and it had long been practised, as we will see in the next section, in the maritime loan (foenus nauticum) taken out for insurance purposes. The doctrine of aleatory contracts both admitted the sale of hope (emptio spei) and the sale of the risk (periculum) to which capitalists voluntarily exposed themselves (Gambino 1964). Despite the fact that the method used to quantify future-related uncertainty was not clear, the sale of this uncertainty was therefore usually considered legal.

In insurance contracts, the lawfulness of this new agreement was justified by the fact that "taking a risk is worth a price" (Vitoria 1934, 219). This lawfulness was then reinforced by the principle of equivalence: the reward, it was said, must be proportional to the danger (Lugo 1652, 447). And since the circumstances are always different, also the danger is always different, so the price is fair if there is

7 Duncan (1972, 313) speaks, in this respect, of "perceived environmental uncertainty".

equivalence (aequalitas) between the price of insurance and the "quantity of the danger" (quantitas periculi) to which insurers expose themselves.

With great acumen, Juan de Lugo (1652, 448) had pointed out that the price of insurance is not charged for the future event, but for the risk of the event. No one, in fact, can predict what will happen in the future. Moreover, one could not explain the difference between premium and compensation, or, lack of compensation, when the cargo respectively is lost, or, arrives safely at its destination. If future events cannot be observed, it is nevertheless possible to observe the possibility of future events. And it is precisely this possibility that must be quantified in order to price the insurance policy. This is the reason why for Pedro de Santarém (1599 [1488], 98) the true matter was not so much to know the value of the cargo, but to estimate "how probable [is] the uncertain event". The premium set, therefore, is not the price of what will happen in the future; it is the price of expectation.[8]

The future as such, indeed, cannot be observed. Nobody finds the date of their death on a mortality table. What one can do, instead, is to observe the future through a *fiction*. One who knows past cases can, for example, compare their number with the overall number of events that have occurred and check whether there is any regularity in this aggregation. If some regularity emerges, the observer has the feeling of being confronted with a kind of "normality of chance": the single event is always contingent and as such unpredictable, but the set of all events suggests that there is some order in contingency, and that this order can even be quantified (Esposito 2007).[9]

This is precisely what happens when measuring the frequency of claims. This frequency refers to the past, but can be projected onto the future based on the assumption that the future will be like the past. Strange as it may seem, in this way it becomes possible to observe the unobservable and, assuming the observation takes a quantitative form, to calculate the incalculable. Precisely in this sense the premium is not the price of the future, but the price of observing the future (Cevolini 2016, 161 ff. [165]). This price replicates, but in a quantified form, the structure of contingent futures according to which the only certain thing we know is that the future is uncertain.[10] And the premium itself, as it is set, unfolds

8 Cf. Santarém (1599 [1488], 98): the insurer only sells the expectation of a future event.

9 Quantification is a condition for comparison, i. e., second-order observation, which in turn is a structural condition for an emerging market of risks. A socio-evolutionary investigation of modern insurance should take it into consideration. See also below section 6.

10 Cf. Aristotle, De int., 9, 19a30–33. A large and subtle dispute upon contingent futures had developed in the Middle Ages, but the approach largely remained theological.

the paradox implicit in the possibility of reducing the uncertainty of the future to a certain price.[11]

3 The functional differentiation of risk-taking as an evolutionary advance

As we have seen, financial risk-taking was nothing new in the Middle Ages, and contracts incorporating it were usually considered lawful. The debate on usury had introduced a clear distinction in this regard: interest (usurae) can be considered as a sale of time, or, as a sale of the risk to which capitalists expose their money. In the latter case, as Pierre de Jean Olivi (2012 [ca. 1295], 208) argued, uncertainty excludes usury, and if the capitalist makes a profit on his capital, it is legitimate.

The maritime loan (foenus nauticum), which since antiquity had performed an insurance function (even if it was not an insurance contract), had posed a problem for late-medieval jurists and moralists precisely because of its ambiguity in this respect: being a loan, the claim to receive something more than capital was to be considered usurious. But in practice, everyone knew that the interest was actually demanded for the risk the capitalist assumed in the commercial enterprise. The ambiguity was thus essentially a consequence of redundancy: the same structure (i. e., capital interest) performed different functions.

The evolutionary advance occurred when the financial risk-taking function (susceptio periculi) was isolated and separated, becoming the sole formal object

11 Cf. Lessio (1609, 336): "Periculum sortis incertum debet reduci ad certum pretium" (the uncertain risk on capital outlay must be reduced to a price that is certain). Lessio dealt here, however, with company agreements in which a party puts in labour and the other party puts in capital, and addressed the question of how future (i. e., uncertain) profit should be divided up. The same reasoning underlies insurance performances. Assuming, for example, that the value of the insured cargo is 200 florins and the premium rate is set at 5 %, the insurer receives from the insured 10 florins as the price equivalent to the danger to which the insurer exposes himself. The eventual loss suffered by the insurer, in the case the cargo is lost, is 200–10 = 190 florins. However, this bare sum is not very informative for the insurer precisely because the future event is unpredictable. If, on the other hand, the insurer estimates the probability of the event to be 5 % (p), then he can consider the risk to which he is going to expose its own capital to be equal to the product of the probability and the total amount of possible loss ($p \cdot 190 = 9.5$). As can be seen, in this case the insurer compares the certainty of the premium received in the present with the estimated uncertainty of future loss. The comparison also convinces him to assume the risk. This fundamental principle of the insurance mechanism goes today by the name of "loss expectation", or, "expected value of a policy".

of the contract (Paoli 1930, 52; cf. also Žiha 2021, 59). This coincided with the placement of the insurer into a position of "third party" to the parties involved in the business (Bensa 1884). Whereas in the maritime loan and commenda, capital and labour remained associated and retained a common interest in the business success, in the insurance contract the insurer alienated himself, so to speak, from the venture in which he did not participate in any way, and limited himself to ensuring compensation in the case of claim. This "third party"-position between the parties was a prerequisite and a consequence, at the same time, of the differentiation of the financial risk-taking function. Third party and differentiation were, ultimately, the same thing.

The effect of this functional differentiation was first and foremost a kind of relief. Merchants who wished to insure their business no longer had to resort to the expedients with which they had been forced to disguise maritime loan agreements made for insurance purposes. For legal scholars and theologians, moreover, there was no doubt that the insurance contract, although atypical, was lawful. Already in the first half of the 14th century, it was accepted that whoever takes the risk of compensating someone else's cargo in case it is lost at sea, should receive a price for the risk assumed.[12] This recognition also made it possible to rehabilitate, a posteriori, the maritime loan contract, yet this was done when the use of this contract for insurance purposes was no longer needed.

A further effect of the functional differentiation of risk-taking was the confirmation of the fact, by no means intuitive, that uncertainty referring to future events can be sold as if it were a commodity. In his analysis of "monte"-contracts (14th-century treasury bills), Francesco da Empoli had pointed out that, when people sell their credit, there is always the risk that the debtor (in this case, the state) will not be able to pay. The one who buys the credit of another can estimate this risk and pay a corresponding price (e. g., buy for 25 florins the credit of 100 florins a person has against the state). The interesting aspect of this analysis lies in the fact that, as Francesco da Empoli (1999 [ca. 1350], 42 [fol. 154r]) clearly argued, estimation is possible not insofar as one foresees the future, but insofar as one assumes that future time is already present. Insurers do the same thing when they sell future-related risks and ensure cargos being transported by sea (Empoli 1999 [ca. 1350], 42 [fol. 154r]; cf. also Pesce 1966, 43). Insurance was thus, from the very beginning, a business of uncertainty and created one of the essential prerequisites for the emergence of a modern risk market. In the late Middle Ages, merchants resorted to a corresponding semantics for this kind of business.

12 See, far ahead of his time, San Concordio (1481 [1338], lemma "Uxura", s. n.). Cf. also Pesce (1966, 42).

4 The uncertainty of merchants

In the second section of this article, we have seen that merchants had a peculiar approach to uncertainty. They made a distinction between future events and the present expectation of future events, and tried to somehow quantify future events-related likelihood. The fact that aleatory contracts were lawful is a striking evidence that uncertainty was not simply a theological issue but a commercial concern that could be faced by means of proper legal and financial instruments. This peculiar manner of dealing with uncertainty required respectively new ideas.

In the introduction of this article, we have seen that insurance contracts used and at the same time contributed to the spread of a new semantic difference, that between risk and danger. The idea of risk is a neologism that made its appearance in the mid-12th century and probably has an Arabic root that spread across Europe, especially through the mediation of merchants and notaries, in the Latinised form 'risicum' (Kedar 1969; Piron 2004). Common counter-concepts of risk were 'periculum' (danger), 'ventura' (venture), 'fortuna' (fortune).

Historical research has shown that originally, the neologism 'risicum' was very often used when it came to speculative investment ('ad laborandum') of another's money, while at the same time freeing oneself from responsibility for a possible loss due to unexpected, fortuitous events. Since the pair of concepts risk and danger cannot be explained as a simple form of redundancy, their difference should have another meaning.

In the documents that used it, the feeling is that the reference to risk was a form of relief from the financial liability implicit in the speculative use of money. The expressions 'ad meum', or, 'ad tuum risicum et periculum' (at my own risk and peril, at your own risk and peril) specify who bears the burden of the eventual loss of ventured capital. In this way, the parties involved in a business not only decided in the present how they had to cope with the future, thus avoiding possible complaints about future consequences of past decisions, but also became confident with self-attribution of losses.

For late-medieval merchants, after all, the matter was not to show their virtue in the face of the unpredictable blows of fortune, but to transform an uncontrollable fortune into a calculated risk. The semantic pairing of risk and danger thus had a very precise function: the admission of the uncontrollability of the environment, i. e., of contingent future events, was separated from the liability for possible damages that these events could bring about. Liability, in turn, created and delimited an autonomous space of possibilities for dealing with the uncertainty of the future – a space that depended on decision-making strategies and allowed the decision-maker to deal with uncertainty in a very peculiar way (cf. Luhmann 1990; 1991, 24 ff.).

Uncertainty, on the other hand, "is one of the fundamental facts of life" (Knight 1921, 347) and, as such, it has always been there. Modern society itself generates more certainty and more uncertainty at the same time compared to pre-modern society. What changes in socio-cultural evolution is rather the way people deal with uncertainty. One possible strategy, which coincides with Church time (Le Goff 2000), is the externalisation of uncertainty.

In the late Middle Ages, the theological and moral treatment of uncertainty was still essentially based on the notion of prudence. The latter required men to moderate their concern (sollicitudo) about the future. Excess, in fact, generates disorder. According to theologians, the causes of disordered foresight could be three: 1) men could turn the future into an end, thus worrying more about what is not than about what is; 2) or, they could try to procure superfluous goods, i. e., goods not indispensable to the needs of their present life; 3) finally, they could worry about future concerns (Thomas of Aquin, S. Th., II–II, q. 55, art. 7).

All of these cases were logically opposed to insurance reasoning. The insured always runs the risk of paying the premium for nothing. The third possibility then took the form of reflexivity: whoever in the summer already worries about the problems that could be reason for concern about the outcome of the grape harvest, risks triggering an endless circularity. But this is, after all, precisely what the insured does: he does not wait until navigation has begun to start worrying about the dangers of navigation, but anticipates in the present the uncertainty of the future, and creates an additional uncertainty that can be subject of decision (should I insure or not?).

The theological and moral interpretation of concern about future uncertainty endures until the end of the 16th century. For Francis Bacon (1842 [1597], 68), man should live in the present and not problematise the future in the present without measure. Excessive concern about worldly cares is not only useless, because it oppresses the mind, but also a profane attitude, because it conceals the hope of "a certain perpetuity in the things of this world". In addition, according to Bacon (1842 [1597], 68), there was the error of those who spun out their cares "to an over great length, and unto times too far off", as if they "could bind the divine providence by [their] provisions".

Underlying this theological and moral interpretation there was, however, a misunderstanding. The future remains uncontrollable even when an attempt is made to control it, for example by means of precautionary measures. By means of provisions, the decision-maker does not bind the future; he rather binds himself by dealing with an uncertainty that is, as always, self-produced. The insurance decision is a form of provision precisely in this sense, i. e., as a binding decision. Compared to the theological-moral conception of prudence, however, insurance conceives uncertainty as something available, therefore, productive of possibilities.

A striking evidence of this availability is the quantification of uncertainty. The insurer can calculate, through an estimate of claim frequency, at what premium rate it can sell insurance in the hope of making a profit. In this respect, insurance is trading uncertainty. The insured, in turn, can calculate how much it costs to manage, in the present, the uncertainty of future events. In this respect, insurance assigns a certain price to the uncertainty of the future (cf. section 2). Insurance thus internalises uncertainty: the future remains uncontrollable, but future-related uncertainty becomes something available which transforms the confrontation with uncertainty into a decision-making process – starting with the decision whether or not to insure. But how was it possible to perform quantification?

5 Fair price between proto-statistical risk assessment and contractual agreement

As we have seen, in the late Middle Ages the problem of insurance business was not how to justify the lawfulness of a sui generis contract that was unknown in Roman law. The problem was, instead, how to quantify uncertainty and establish that the price to be paid for a policy was fair (Ceccarelli 2001). Already at the end of the 13th century, Pierre de Jean Olivi (2012 [ca. 1295], 212) had pointed out that in a partnership agreement (commenda) in which one party puts in labour and the other puts in capital, the party putting in the capital can legitimately claim interest that depends on how "probable" (sic) the future profit is estimated on the basis of a "rational assessment" of circumstances.

According to Olivi (2012 [ca. 1295], 216), the "value of probability", i. e., the value of the hope of a probable profit to be made from the ventured capital, is "appreciable" both in the sense that it can be estimated in some way, and in the sense that the estimate is quantifiable in the form of a pre-determined price. On the other hand, legal scholars argued that there must be equivalence between the price and the danger to which people actually expose themselves in order for the price to be fair. This is precisely why it was so essential to find a way to calculate dangers, i. e., the likelihood of future damages.[13]

Giovanni Ceccarelli has showed in full detail that risk estimate essentially depended on two main assessments:

13 Salón (1608, 682) had pointed out, for example, that the price of an insurance policy must be "commensurate with the danger" for which that price is paid. He had in addition argued that this price depends on the greater or lesser value of the cargo, but first and foremost on the greater or lesser risk to which the insurer exposes himself.

(a) the first was a pseudo-frequency estimate based on proto-statistical reasoning;
(b) the second was an estimate based on the experience of so-called "risk experts", i. e., brokers and leading insurers (Ceccarelli 2010).

Indeed, Alberto Tenenti (1997, 1583) had already suggested that in late-medieval and early-modern maritime insurance contracts, premium setting was based on a "pre-statistical" and yet somehow rational estimate. And even earlier, Ugo Tucci (1981, 149 ff.) had observed that the (Venetian) insurers of the 16th century were certainly not completely lacking in technical expertise and statistical knowledge, especially being at the centre of "a dense network of information exchange" concerning everything that could affect risk assessment.

A test of the hypothesis that premium rates coincided with the estimated frequency of claims could only come from a comparison of claim frequency with the total number of commercial trips made under certain conditions over a certain period of time. To the best of my knowledge, one of the few attempts at such a comparison is the one made by Alberto Tenenti for ships insured in Ragusa (Dubrovnik) in the period between 1563 and 1591.

Tenenti's investigation has shown that the frequency of claims in that period had been 5.22 % and that this frequency was very close to the average rate of the insurance contracts taken out (A. Tenenti 1985, 411; cf. also Tenenti/Tenenti 1985, 247). To this provisional evidence one should add that, as Benjamin Scheller (2017, 69 ff.) has pointed out, many merchants used to keep separate accounting books for insurance contracts. In these ledgers, insured and uninsured sea voyages were recorded, and for each contract entered into actively or passively, the final outcome (the ship had arrived safely, or, the cargo had been lost, and the merchant had provided compensation, or, had been compensated) was also recorded.

This insurance book-keeping simultaneously offered at least three crucial pieces of information: on one hand, it allowed the merchant to get an idea of the ratio between the number of claims and the overall number of insured cargos. Thus, taking into account the overall number of trips made (which also included uninsured cargos), the merchant could calculate the claim frequency and his personal loss ratio. Since the accounting was periodic (usually one year), the merchant further obtained another essential measure: the dispersion of cases over time (Scheller 2017, 71).[14] In this way, it was possible to quantitatively verify the

14 Scheller (2017, 72) has gone so far as to speculate that the statistical calculation of probability has its origins in the late-medieval insurance book-keeping.

possibility that lucky cases did offset the unlucky ones, and this not only on the social dimension but also on the temporal dimension.

Lorraine Daston's (1987, 240) claim that until the 17th century the policy premium setting "was not simply astatistical; it was antistatistical" is therefore, in my opinion, disputable. Historical research offers much empirical evidence that premium setting rather pursued a proto-statistical approach based on an estimation of the average claims frequency – an estimation that depended on an intensive gathering of information on the main European insurance markets and the scrupulous accounting of merchants involved, both actively and passively, in the business of insuring maritime trade.

Since, however, the calculation of uncertainty remains uncertain because no one can say with certainty whether the quantification of expectation is right or wrong, the only way to solve an unsolvable problem remains the *agreement of the parties* involved in the contract.[15] This is precisely the reason why dealing with the uncertainty of future events must be subject of a contract.

The function of (insurance) contracts is not really to produce consent: both parties may continue to think that the premium is not equivalent – despite all calculations – to the risk actually assumed by each of them (although neither party is able to prove it). Rather, the contract serves to mutually limit what the parties may expect from each other, thereby also implicitly specifying what it is that the parties may not demand. Therefore, the product of the agreement in the insurance contract is the agreement itself (Luhmann 1996, 281).

Late-medieval insurance remained, however, mostly a form of gambling. Yet it must be clarified in what sense this is to be understood. To clarify this statement, one can turn to the important distinction introduced by Ludwig von Mises (1998 [1949], 106 ff.) between case probability and class probability.

According to von Mises, "case probability" is a contradiction in terms since the singular event is itself unpredictable. Any probability estimate associated with the individual case depends on a calculation that starts from the class to which the case belongs. The probability assigned to the individual case is thus a probability of the case *as a member* of a given class. For the case *as such* (as for any real future event), one can only speak of pure chance, which means that the individual case escapes any calculation and remains as such unpredictable. Only a class can be calculated.

Late-medieval insurance contracts, as we have seen, have this particular feature: they were stipulated on the individual case (this cargo loaded on this

15 Very clear on this point Pothier (1775, 87, § 82): "Mais comme il n'est pas facile de terminer quel est ce juste prix, on doit [...] réputer pour juste prix celui dont les parties sont convenues entr'elles".

ship for this trip), but they quantified the premium based on an estimate of claim frequency. These contracts should therefore be regarded as gambles not because some form of statistical-probabilistic calculation was lacking, but because the practice of distributing losses over all members of the same class was lacking.[16]

Precisely in this sense, as von Mises (1998 [1949], 109) states, the "basic idea [of insurance business] is pooling and distribution of risks, not the calculus of probability". It is only in the distribution of losses among all members of the same class, in fact, that that particular effect of insurance business is generated whereby it is advantageous for everyone to share the uncertainty of the other members of the same class, since only in this way can everyone be certain of being financially covered in the event of a loss.

Even this principle, however, had not escaped the early-modern merchants who made insurance business. In his famous treatise on commerce, Benedetto Cotrugli (1602 [1458], 75) had recommended to underwrite "continuously, & upon every ship, because the one offsets the other, & by pooling, [the insurer] cannot but make a profit".[17] In this way, Cotrugli had brilliantly and well ahead of his time formulated the second fundamental principle – after the principle of loss expectation – underlying modern insurance business. I would like to focus on this point more extensively and then draw some conclusions.

6 Overcoming chance by means of chance

The implementation of the risk pooling and spreading mechanism took place definitively when insurance became a joint stock company based on actuarial calculations. This transformation occurred rather late, between the first half of the 18th century and the first half of the 19th century. The reasons for this delay, or even for the resistance of society to the establishment of insurance companies, are manifold and it is not easy to trace them back. Antonio La Torre (2000, 198) speaks, in this respect, of a transition from (separate) "acts" to (entrepreneurial)

16 If the insurer calculates – to repeat von Mises' example –, in a class of ten persons, a one in ten chance (10 %) that a loss of 100 € will occur, he can charge each person 10 € premium and thus ensure compensation for all without the insurer suffering any loss in turn. But if the insurer, all things being equal, insures only one person in return for a premium of 10 €, his action becomes a form of gambling: the insurer can win 10 € or lose 90 €.

17 Cf. also Nehlsen-von Stryk (1989, 199 ff.) according to whom this source is evidence that insurance was practised as a "serious business", not as a mere gambling.

"activity".[18] In this way, however, the problem is simply indicated, not solved. Insurance becomes modern, one might say, when spread becomes pool-and-spread, but this is precisely what socio-historical research should explain.

In this section, there is only room to consider some consequences of the doctrine of aleatory contracts on the idea of probability underlying mathematical calculus. As Lorraine Daston (1988) observed, the development of classical probability theory has been driven more by legal problems than by mathematical ones. Because these problems – especially, equity and the determination of fair price of aleatory contracts – were already present in the late Middle Ages, one wonders however why probability theory had not been developed earlier (Coumet 1970).

Although a calculation of probability had already been performed in the mid-16th century, it did not become widespread until a century later and began to penetrate insurance practice in the early 18th century (Hacking 1975; 1990). It was not until the late 18th and early 19th centuries, however, that statistical-probabilistic calculation was firmly applied to support insurance practice, which in the meantime had taken the form of joint stock companies. It is therefore not easy to explain why a calculation that, as Daston (1987, 237 ff.) has pointed out, was custom-made for insurance practice has been so long neglected.[19]

A sociological hypothesis is that statistical-probabilistic calculation, before being employed in insurance practice, had to overcome not so much mathematical problems as plausibility thresholds. The first and perhaps most important, at least for the modern insurance industry, is what is now usually termed "law of large numbers". Underlying this law there is the idea that, while the individual case is unpredictable, the aggregation of many similar cases gives rise to regularities that can be very useful when it comes to decision-making.

As we have seen (section 2), even a simple calculation of claim frequency can create a kind of "secondary normality" (Luhmann 1991, 1): in everyday life, normality is sometimes interrupted by unpredictable and somewhat painful events, but as a whole these events recur with surprising regularity, so that one can draw the conclusion that accidents are normal "and in that sense not accidents at all" (Ericson et al. 2003, 47).

From a socio-systemic viewpoint, the law of large numbers is a way of dealing with complexity. Cases are randomly distributed not only in the population, but

18 It is clear that in the former case the aleatory character (consequently, the gambling nature) of the agreement is more pronounced.

19 Clark (1999, 114 ff.) partially revised Daston's historical reconstruction, showing how life insurance did not completely ignore statistical and probabilistic calculation. Clark (1999, 117), however, admits that this was done very reluctantly, at least until the establishment of the Equitable Society in 1762.

also over time. No one can predict *who*, in the reference social group, will be affected by a misfortune, and no one can know *when* exactly this will happen. The interplay between these two – the social and the temporal – dimensions greatly increases the complexity with which a decision-maker acting under conditions of uncertainty must deal.

The striking aspect of the insurance principle of risk pooling and spreading lies in the fact that it turns this complexity, which is first and foremost a problem, into a solution. Indeed, it is the social and temporal aggregation of similar cases that creates those regularities that the insurance industry can rely on when it sets the policy premium so that premiums collected in the past are sufficient to cover the claim compensations the industry expects to face in the future.[20] The spread of chance in the pool and over time is, in other terms, an unsolvable problem only if one reasons in terms of individuals. It becomes a solution, instead, if one reasons in terms of aggregations. Insurance, being an aleatory contract, takes advantage of this opportunity when it calculates the "lawfulness (Gesetzmäßigkeit) of chance" – that is, when it uses chance to overcoming chance (Hülße 1916).

For early-modern insurance companies, however, this meant accepting the not immediately obvious idea that increasing risks means reducing risks taken by the company (that 'susceptio periculi' which had been exercised rather sporadically in the late Middle Ages, as we have seen). Statistical and probabilistic calculations contradicted, in this respect, common sense and required a special effort to accept the credibility of what looked like a paradox. Ultimately, it was a matter of accepting the idea that increasing uncertainty could make insurance business safer (cf. Daston 1988, 115).

This implied a second form of implausibility: the calculation could also show that there are regularities in the social and temporal distribution of chance, but nothing could then ensure that those regularities were regular. If uncertainty could somehow be calculated, the issue remained as to how to ensure that the results of calculations were a reliable basis for decision-making. It was not just a matter of believing "in the reality and stability of averages" (Daston 1988, 115). It was more radically a matter of dealing with the reflexivity of uncertainty – that is, with the uncertainty of the calculation of uncertainty.

For insurance companies, this meant not only improving their methods for calculating bets, but also betting on (the reliability of) calculations (Cevolini 2014, 198 f.; 2016, 167 ff.). Moreover, the function of calculations is not to remove uncer-

20 Babbage (2000 [1826], 249) presented this argument very clearly: "Nothing is more proverbially *uncertain* than the duration of human life, when the maxim is applied to an *individual*; yet there are few things less subject to fluctuation than the *average* duration of a *multitude of individuals*" (italics added).

tainty. Without uncertainty, there would be no decision to be made, and insurance business would reduce to a profitless routine. Rather, the environment gets noticed not only as error in the calculation, but also and above all as uncertainty about the results of calculations. That is, as what remains uncalculated every time one tries to calculate the uncertainty related to environmental events.

Such a reflexivity had prompted the Law Officers of the Crown to deny the *Society for Equitable Assurances* permission to be a joint stock company. The Equitable Society, on one hand, had reasonably argued that "although the lives of men *separately* taken are *uncertain*, [the expectancy] in an *aggregate* of lives is reducible to a *certainty*" (Society for Equitable Assurances 2000 [1762], 363; italics added). The Law Officers, on the other hand, had argued that the success of these innovative actuarial schemes "must depend upon the *truth* of certain calculations taken upon Tables of Life and Death, whereby the *chance* of mortality is attempted to be reduced to a *certain standard*", and added that "this is a mere speculation never yet tried in practice, and consequently subject, like all other experiments, to various *chances* in the execution" (quoted in Rosin 1932, 61; italics added).

Finally, there probably was a further plausibility threshold to overcome. Lorraine Daston (1987, 238 ff.) observed that gambling and insurance shared, as aleatory contracts, the idea that a bet is fair if both players have the same odds. If instead one of the players, whatever the reason may be, has higher odds of winning, the play is not fair. In the case of insurance agreements, indeed, the situation could appear unequal in favour of the insurer: by playing on large numbers, the insurer can calculate the bet and have a high chance of profit. The insured, on the other hand, is confronted with a single chance, hence with a genuine and by definition incalculable uncertainty.

Geoffrey Clark (1999, 117 ff.) has partially rectified Daston's historical investigation. According to Clark, in the 18th century many policyholders bought life insurance for prudential, not merely speculative, purposes, and both early insurance promoters and customers did appreciate the use of statistical and probabilistic methods.[21] It should also be reminded that in 1774, the Gambling Act had prohibited the purchase of insurance cover where the insured did not show a clear "interest in being insured" (Merkin 1980). This legislative act confirms, on one hand, Daston's argument (1987, 244) according to which insurance had for a long time been "fueled more by the spirit of gambling than of foresight"; but it also shows, on the other hand, how the time was ripe to separate insurance from betting. The Gambling Act introduced a restriction which – as always in evolu-

21 See also footnote 19.

tionary advances – opened up the possibility of insuring practically anything, provided one could prove an interest in being insured.

The change in attitude towards insurance between the second half of the 17th century and the first half of the 19th century, however, cannot be explained on the level of the evolution of ideas alone. The transformation of social structures produced by functional differentiation should also be taken into account. The case of insurance is, in this respect, a striking evidence of how complex the interplay of social structures and ideas is, and that socio-cultural evolution cannot be reduced to causal interpretations of this interplay.

The success of insurance in modern society goes hand in hand with a generalisation of risk orientation. In terms of social structures, this means that solidarity against dangers is gradually replaced by a risk market (Cevolini 2014, 196 ff.). One effect of functional differentiation, on the other hand, is precisely the exemption of interaction systems and typically medieval mutual-help associations from many of their functions. The latter are assigned to social subsystems that implement them through their own organisations. As the function of education, for example, no longer takes place in the family but is assigned to the education system through schools and universities, so many welfare and provision functions previously implemented by family networks and self-help corporations are assigned to the money mechanism-based economic system, which implements them through business companies (Ryffel 1970, 3 f.; Ewald 1989, 386 f.; Luhmann 1996, 281).

This opens up a field of research still largely unexplored by the sociology of risk and insurance. An investigation into the structural changes of modern society should explain the transition from "concrete mutualities" to "abstract mutualities" (Ewald 1991, 203); how this transition coincides with the emergence of secondary structures, i.e, structures characterised by the fact of being "non-interactional ways of relating to others" (Luhmann 1987, 118); and how a correlate of these structures are all those pools of policyholders that actuarial calculations create as "fictions" (Rohrbeck 1949, 240) which make, in the end, the insurance business work.

7 Conclusions

I would like to draw, now, some provisional conclusions. Although the approach of this article is that of historical sociology, I argue that the origins of insurance contract in the late Middle Ages and the establishment of insurance in modern society could be better understood if one adopted a socio-evolutionary perspec-

tive. The late-medieval insurance contract, as we have seen, already offers many clues in this regard.

This contract had, both on a technical-legal and semantic level, several innovations behind it that prepared the creation of a new contractual instrument. The maritime loan already performed an insurance function, even if only secondarily. And interest (usurae) had, in turn, a "dual function", as Rudolf Jhering (1881, 19 ff.) already argued: it could represent the gain that the capitalist obtained in addition to the lent capital (ultra sortem), or, the price of the risk taken on the capital (susceptio periculi).

Evolutionary advancement, on the other hand, always implies a functional change: a structure previously employed to perform a certain function is co-opted to perform a function that was previously only secondary. The new function becomes primary, while the old function recedes and eventually disappears. This enacts a corresponding structural change (Luhmann 1997, 505 ff.).

Both these conditions – a long phase of latent preparation, and a functional change – can be found in the origins of the insurance contract. These assumptions make it possible to explain the origin of insurance as a true socio-evolutionary novelty. They do not, however, explain why insurance did not remain confined to maritime trade but became a core institution of modern society. Sociological theory of modern society suggests that this occurred as a result of structural transformations that depend on functional differentiation and the increasing abstraction and complexity of secondary structures that this form of differentiation brought about.[22] This is where, in my opinion, one should start in order to explain the competition between pre-modern forms of self-help associations and modern insurance companies; the initial resistance to the use of statistical probability calculation for insurance purposes; and the reasons why, in the end and despite everything, insurance could establish as an irreplaceable institution of modern risk society.

This socio-evolutionary approach could also confirm the hypothesis underlying this article. If it is true that since its late-medieval origins, insurance had been able to identify the two essential principles that make the modern insurance mechanism work (that is, the principle of loss expectation, and the principle of risk spreading), it is also true that only under the conditions produced by the structural transformations of modern society does the latent potential of these two principles become evident. If, therefore, a statistical calculus of probability

22 Luhmann (1996, 274) pointed out, in this respect, that it is not modern society that takes advantage of insurance; it is rather insurance that takes advantage of (the structures of) modern society.

for insurance purposes was first performed in the mid-17th century, it was not because of a *deficit of ideas*, but because of a *deficit of social structures*.

Historical investigation and sociological theory should work together to deepen and possibly confirm the hypotheses schematically presented in this article. The result would certainly be a great contribution to a history of insurance from a global perspective and to a sociology of insurance.

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