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EDITORIAL

Decentralized insurance: On the popularity of tontines and peer-to-peer (P2P) insurance schemes

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Insurance business is typically based on a risk transfer from individuals to an insurance provider by means of bilateral contracts. Growing in importance, if less common, are mutual or decentralized insurance schemes, where pools or communities share the risk without the need of a centralized insurance provider. The latter has been known for many centuries. In the 17th century, for example, fire insurance policies in Great Britain or (retirement) tontines were based on the idea of sharing risks within a pool of individuals. At its core, both the traditional insurance business and decentralized insurance schemes are based on the concepts of risk pooling and diversification. An important difference lies in the treatment of the deviation between actual and expected claims: In traditional business, this risk is taken by the insurance provider (for a cost) while in decentralized insurance, such deviations are absorbed by the pool of individuals. In life insurance and pensions, the two extremes would be a defined benefit contract, where retirement benefits are fixed and guaranteed by a centralized insurance provider, and a collective defined contribution contract, where risks stay with the pool of contributors.

We distinguish different types of decentralized risk sharing: First, following Dhaene & Milevsky (2024), there are two types with respect to the payment streams, namely (i) *decentralized risk-sharing systems* and (ii) *retirement tontine arrangements*. The latter assumes that each participant contributes premiums ex-ante to the pool. This pool money is redistributed in case of insurance events (like death or health incidents). In contrast, a decentralized risk-sharing system does not fix an ex-ante premium, but the contributions are determined ex post such that they cover incurred losses. Second, we can distinguish according to the way risks are shared according to *aggregate risk sharing* and *peer-to-peer* (P2P) *risk sharing*. Aggregate risk sharing is derived from economic principles, such as Pareto optimization of participants' expected utilities. A key feature of these risk-sharing schemes is that participants' risks are aggregated and then allocated among participants, see the classic article Bühlmann & Jewell (1979). In P2P risk sharing, risks are traded directly pairwise among participants without going through a process of aggregation. Recent works include Charpentier et al. (2021), Abdikerimova & Feng (2022) and Feng et al. (2023). A summary of a variety of decentralized insurance schemes can be found in Feng (2023), where a decentralized insurance scheme is viewed as a composition of risk transfer rules and risk-sharing rules. Although often not explicitly stated this way, the notions of decentralized risk sharing in

multi-period models are also present and developed separately in the actuarial literature on tontine and other annuity-like retirement plans (as examples, see Chen et al., 2019; Denuit et al., 2022; Donnelly et al., 2013; Hieber & Lucas, 2022; Milevsky & Salisbury, 2015, 2016). An example of multi-period P2P risk-sharing models can be seen in Abdikerimova et al. (2024).

Research directions

Starting with Karl Borch in the 1960s, a large body of actuarial and economics literature on risk sharing has evolved. We want to point at some interesting research directions.

While the case of a homogeneous pool with equal contributions is rather simple, as proceeds are just divided equally among pool members, the heterogeneous pool case turns out to be much more involved, especially for relatively small pool sizes. This leads to questions of actuarial fairness, see Dhaene & Milevsky (2024) for a recent discussion and further references. Starting from the canonical mean proportional sharing rule, this asks for a comparison and also axiomatization of different sharing rules. Useful properties of risk-sharing rules are described and motivated in, e.g., Denuit et al. (2022). Jiao et al. (2024) demonstrate that reasonable axioms of a risk-sharing scheme are often not satisfied. The authors demonstrate that a good candidate to share heterogeneous losses in modern participative insurance schemes is the so-called conditional mean risk-sharing rule introduced in the actuarial literature by Denuit & Dhaene (2012). In this sharing rule, contributions by each agent are their conditional expectations, given the aggregate loss of the pool. The resulting allocation is regarded as being beneficial by all risk-averse economic agents, whatever the distribution of the losses or their dependence structure. Under positive regression dependence of individual losses in their sum, the conditional mean risk sharing is Pareto-optimal, see Denuit & Robert (2023b) and the references therein for a more detailed discussion.

Risk sharing of life-related risks, mortality or longevity, is now well studied and effective mechanisms are available in that respect. Risk sharing of health-related risks is comparatively much less developed. Nonetheless, there are successful initiatives on the market, like Medishare, which is the US largest health care sharing community, with more than 400 thousand members. Considering disability, adopting the multistate approach seems to be promising. These models are known to provide an effective representation for generalized life insurance contracts, including life insurance policies, disability insurance policies, and permanent health insurance policies (Pitacco, 2014). First attempts to design risk-sharing schemes in a multistate setting are due to Chen et al. (2022) and Hieber & Lucas (2022). The latter proposed a new risk-sharing scheme called life-care tontine and discuss its potential use to cover long-term care (LTC), while the former proposed different ways of combining LTC with retirement tontines, introducing care-dependent tontines that provide increased payments in care-dependent states. In both papers, processes are hierarchical, in the sense that when a state is left, it can never be re-entered. Extensions allowing for multiple sojourns in the disability state appear as to be relevant when dealing with younger ages (see e.g. Kabuche et al., 2024 where a matrix-based methodology for pooling mortality risk across heterogeneous individuals classified by functional disability states and chronic illness statuses is proposed). This may allow for a proper modeling of the risk-sharing scheme introduced in the Netherlands to mutually protect against the economic consequences of disability, where self-employed workers started a "gift circle" called "bread fund," or broodfonds in Dutch (Oostveen, 2018).

In existing models, severities are proportional to the time spent in disability (assuming a constant rate of benefits) so that severities are not known at occurrence time but only when disabled participants recover. Meanwhile, an initial provision is constituted when a disability claim is reported to the pool, whose amount is adjusted over time. It is therefore important to account for settlement delays in insurance risk sharing. For instance, Denuit & Robert (2023a) explain how to distribute losses at occurrence time in the compound Poisson risk model: each time a claim is reported, the corresponding severity is allocated among all pool members according to

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the conditional mean risk-sharing rule. But this is possible only because severities are assumed to be observable at reporting time, without delay. If severities are not known at occurrence time, then participants are required to contribute an initial provision when a claim is reported to the pool, whose amount is adjusted over time, converging to the conditional mean risk allocation when the claim severity gets known at closure. Claims developing slowly over time can also be sold by the community to an insurance company, freeing participants from future revisions in loss amounts.

Parametric insurance is another area where developing appropriate risk-sharing solutions appears to be promising, with the potential to allow for covering emerging risks. Consider for instance a group of individuals who wish to be hedged against a disaster risk using parametric insurance. When a disaster occurs, members of the group are compensated very quickly on the basis of a suitably selected reference index (or parameter). However, the compensation could be quite different from the actual damages suffered by the victim due to basis risk, i.e., the risk that the compensation does not match actual losses because of imperfect correlation with the index. This is an important limitation of parametric insurance. Hence, the idea to supplement parametric insurance with a P2P basis risk-sharing mechanism. Parametric insurance supplemented with basis risk pooling has the potential to significantly expand insurance coverage, especially in developing countries. International insurance groups could provide populations with parametric insurance while P2P communities would operate at a local level. The same mechanism could be relevant for the supply with energy or agricultural goods, where individual departures from a reference production level could be shared among participants, offering them more stable revenues.

Decentralized insurance products

The market for decentralized risk-sharing systems is growing all over the world but is nevertheless still at its infancy. Examples include digital startups like Lemonade in Europe, online mutual aid platforms in China, or catastrophe risk pooling in Caribbean countries. Since the Caribbean Catastrophe Risk Insurance Facility was successfully launched by the World Bank in 2006, risk pooling schemes have spread to many other parts of the world, including the African Risk Capacity (ARC), and the Pacific Catastrophe Risk Assessment, and Financing Initiative. For a discussion of catastrophe risk pooling and its proliferation around the globe, we refer to Bollmann & Wang (2019) and Ciullo et al. (2024). Online mutual aid also emerged in China as early as 2005 as an alternative to commercial critical illness insurance. As there was a gap between China's national health insurance program and people's needs for healthcare coverage, online mutual aid provided an affordable alternative and was also used by many tech firms such as Alibaba to enter the insurance market. Many mutual aid platforms were hugely successful and amassed over 300 million users around 2020–2022 (see Abdikerimova & Feng, 2022). However, mutual aid met with heavy scrutiny from the regulator. Although mutual aid was never prohibited, many large firms exited the market due to regulatory uncertainty. Takaful insurance, an Islamic or sharia-compliant alternative to conventional insurance, is another example where (variants of) decentralized insurance are implemented. Takaful insurance is already largely popular in the Middle East. It reached a market size of 33.6 billion USD in 2024 and is expected to continue its rapid growth.[1]

In 2024, regulatory concerns still impede the widespread distribution of decentralized insurance schemes. However, its advantages of low costs and high transparency may help them to more significantly complement the traditional insurance business in the future.

FADeRiS conference series

To foster the exchange on different aspects of decentralized insurance and to create and maintain an academic forum for research on decentralized risk sharing and its applications, Michel Denuit

[1]For more details on insurance providers, the development and the size of the Takaful insurance market, see the webpage https://www.imarcgroup.com/takaful-market.

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(UCLouvain), Jan Dhaene (KU Leuven), and Mario Ghossoub (University of Waterloo) started an initiative baptized FADeRiS (*Foundations and Aplication of Decentralized Risk Sharing*). Its aim is to exchange on practical and theoretical advancements in decentralized risk sharing. A first workshop took place at KU Leuven in May 2023. The second edition was held at the University of Ulm at Castle Reisensburg in Germany in May 2024.

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