

Better Together?

How Externalities of Size Complicate Notions of Solidarity and Actuarial Fairness

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Summary of Results. Consider a cost-sharing game with players of different contribution to the total cost: an example might be an insurance company calculating premiums for a population of mixed-risk individuals. Two natural and competing notions of fairness might be to a) charge each individual the same price or b) charge each individual according to the cost that they bring to the pool. In the insurance literature, these general approaches are referred to as *solidarity* and *actuarial fairness* and are commonly viewed as opposites.

However, in insurance (and many other natural settings), the cost-sharing game also exhibits *externalities of size*: all else being equal, larger groups have lower average cost. In the insurance case, we analyze a model called *insolvency-based pricing*, where externalities of size occur due to a reduction in the variability of losses. However, all of our results hold more broadly and apply to all submodular cost functions with strict benefits to pooling. We explore how cost functions of these types complicate traditional understandings of fairness, drawing on literature in cooperative game theory analyzing which arrangements of pooled actors are *stable* against deviations by groups of actors.

First, we explore solidarity: we show that it is possible for players of both types (high and low cost) to strictly benefit by joining a pool where costs are evenly split, as opposed to being in separate pools. Moreover, we show that such an arrangement can also be stable against deviations by any subgroup of actors. We build on this by producing a pricing scheme that maximally subsidizes the high cost group, while maintaining stability (i.e., all subgroups, including the lower cost group, are incentivized to remain in the insurance pool).

Next, we analyze actuarial fairness. We demonstrate that with strictly submodular cost functions, the price charged to each individual has to depend on the cost of other participants, making naive actuarial fairness inefficient. Furthermore, we prove that stable pricing schemes must be ones where players have the incentive of desiring riskier (more costly) partners, contradicting motivations for using actuarial fairness. These results indicate that the motivations for actuarial fairness may require some re-conceptualization. Finally, we describe how these results relate to debates about fairness in machine learning and potential avenues for future research. The full paper is available at [1].

References

- [1] K. Donahue and S. Barocas. Better together? how externalities of size complicate notions of solidarity and actuarial fairness. In *Proceedings of the 2021 ACM Conference on Fairness, Accountability, and Transparency*, pages 185–195, 2021. Available at <https://arxiv.org/abs/2103.00347>.