Axiomatic analysis of liability problems with rooted-tree networks in tort law

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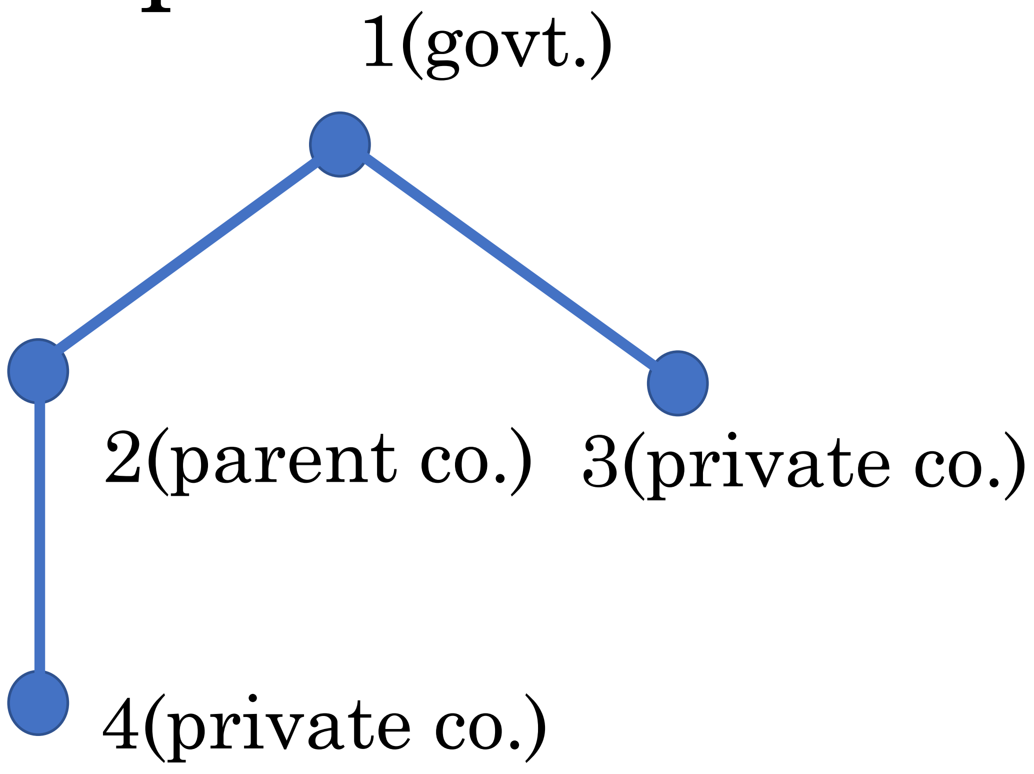
Purpose/ Motivating example

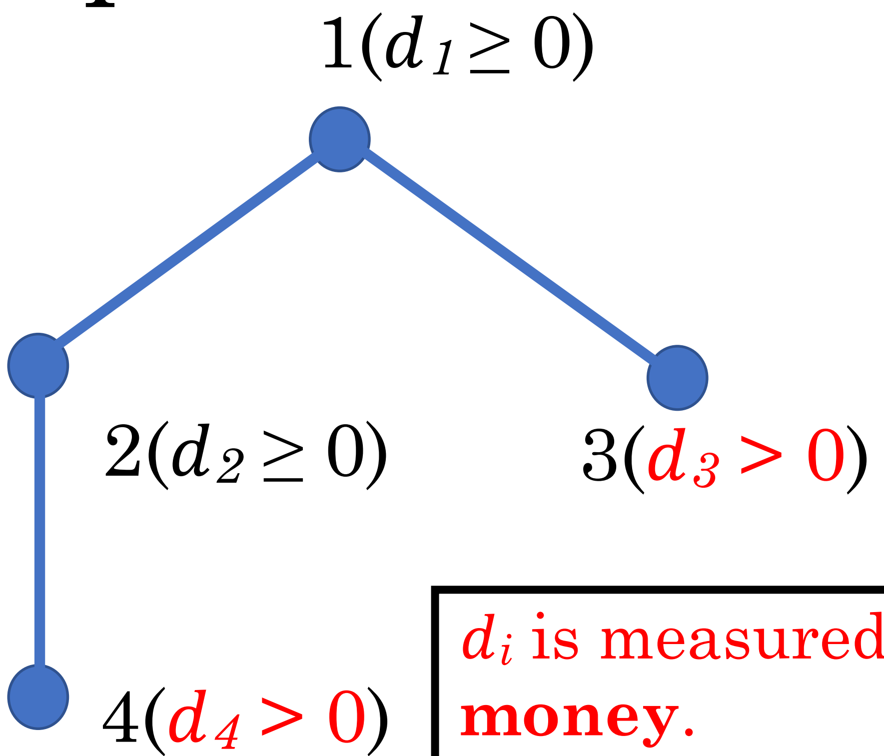
- We analyze a legal situation in which a plaintiff suffers the total damage of the cumulative injury that is caused by multiple sequences of tortfeasors' wrongful acts.
- In many liability situations, a sequence of causal relations among tortfeasors may be represented by a rooted-tree network.
- Question: How should the court decide on a fair apportionment of responsibility among the tortfeasors while respecting relief of the plaintiff?
- This is an important issue in tort law (Boston 1995-1996).
- From the view of axiomatic analysis
- Our axioms are inspired by tort law.



This example is inspired from the first Nishiyodogawa Air Pollution Lawsuit, Japan (1978).

Model based on the example

- A **liability problem** $(N,T,d) \in \boldsymbol{L}$
- $N = \{1,,,4\}$ $T = \{(1,2)(2,4)(1,3)\}$
- d_i is the marginal damage of $i \in N$.
- d_N is the total damage.
- An allocation $x \in \mathrm{R}^N_+$ s.t. $\sum_N x_i = d_N$
- A rule φ on $\boldsymbol{L}$ that associates with every $(N,T,d) \in \boldsymbol{L}$, an allocation.
- The court applies a rule to every liability problem.
- A rule is based on several legal notions that are familiar with the court.



d_i is measured in **money**.

Since leafs are the tortfeasors who had the last opportunity to prevent the harm, the marginal damage of every leaf is assumed to be positive.

Legal notions from tort law

- The Additional Damage (AD) of tortfeasor i is the sum of marginal damages that would have been avoided when tortfeasor i exercised no wrongful act.

- Last-clear-chance of a tortfeasor means that the tortfeasor has the last opportunity to prevent the harm but failed to use reasonable care to do so.

- The per-capita method is a method that the court uses to form her estimation on how much every tortfeasor has to pay. The per-capita method appears in the divided-damage rule in Maritime Law.

- The last clear chance doctrine says that the court takes into consideration that the tortfeasor associated with the last-clear-chance is liable for the harm even if the plaintiff showed contributory negligence.

Legal notions from tort law (Cont.)

- A proximate cause of the additional damage of tortfeasor $i \in N \setminus \{1\}$ is defined as

(i) the set only containing tortfeasor i, and

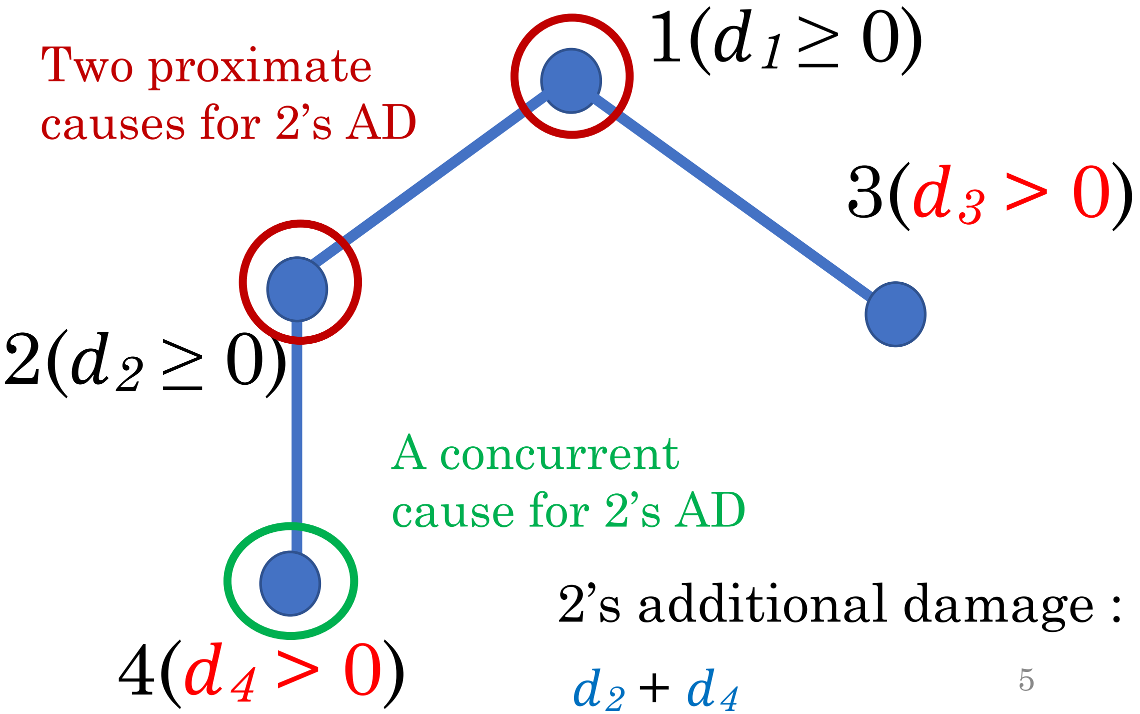
(ii) the set containing all predecessors of i.

Why (ii) as an *indivisible* cause?

The court usually asks for proving the proximate cause in question by a plaintiff, but the plaintiff's transaction cost for proving the proximate cause is high, and thus she cannot prove divisibility of the proximate cause.

- A concurrent cause of the additional damage of tortfeasor $i \in N \setminus \{1\}$ is defined as

the set containing all successors of i.



2's additional damage :

$d_2 + d_4$

Individual Upper Bounds

- *Restatement of Torts: Apportionment of Liability (Third, §A19, §B19)*

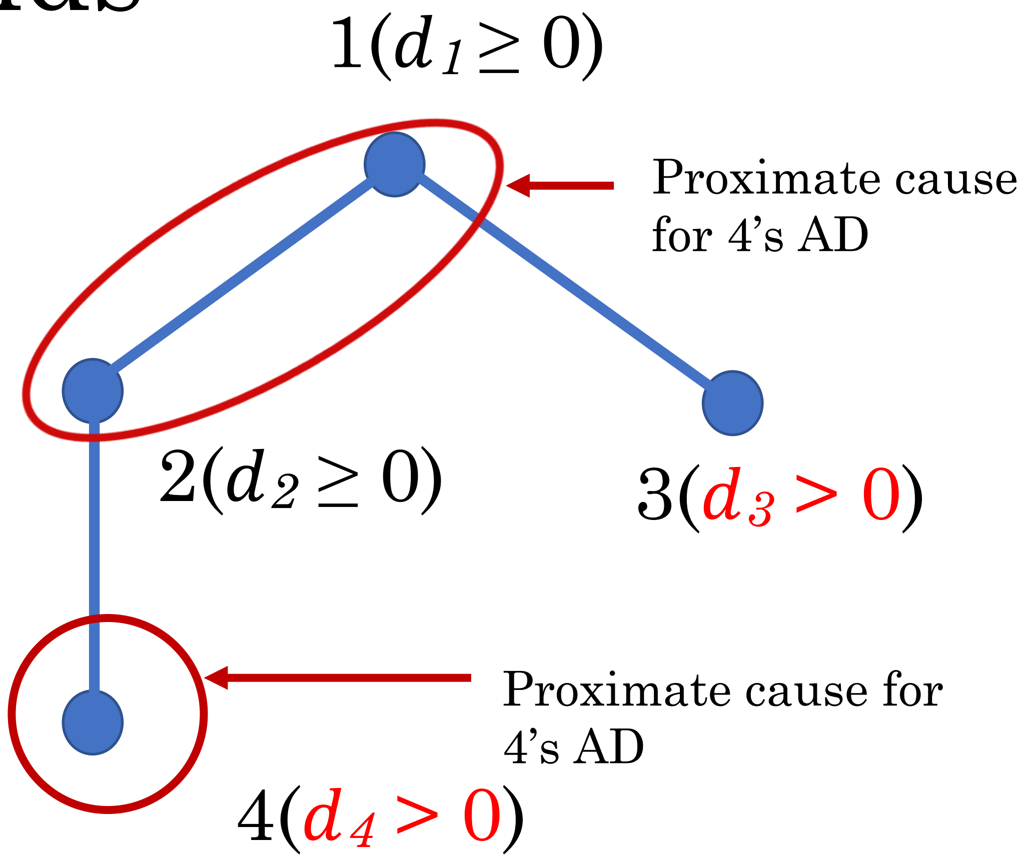
For i=2,3,4,

$\varphi_i(N,T,d) \leq 1/2 \times$ i's *Additional Damage*

$\varphi_1(N,T,d) \leq$ 1's *AD*

Why 1/2 ? (Here, focus on $i = 4$)

- Suppose that the court determines that legal responsibility for 4's additional damage is limited to both only proximate causes.
- By using the per-capita method, the court finds that tortfeasor 4's payment should be at most a half of 4's additional damage.



- 1's additional damage: d_N
- 2's additional damage : $d_2 + d_4$
- 3's additional damage : d_3
- 4's additional damage : d_4

Uniform Lower Bound

- *Restatement of Torts: Apportionment of Liability (Third, § D18)*

For i=1,2,3,4,

From the same logic

$\varphi_i(N,T,d)$

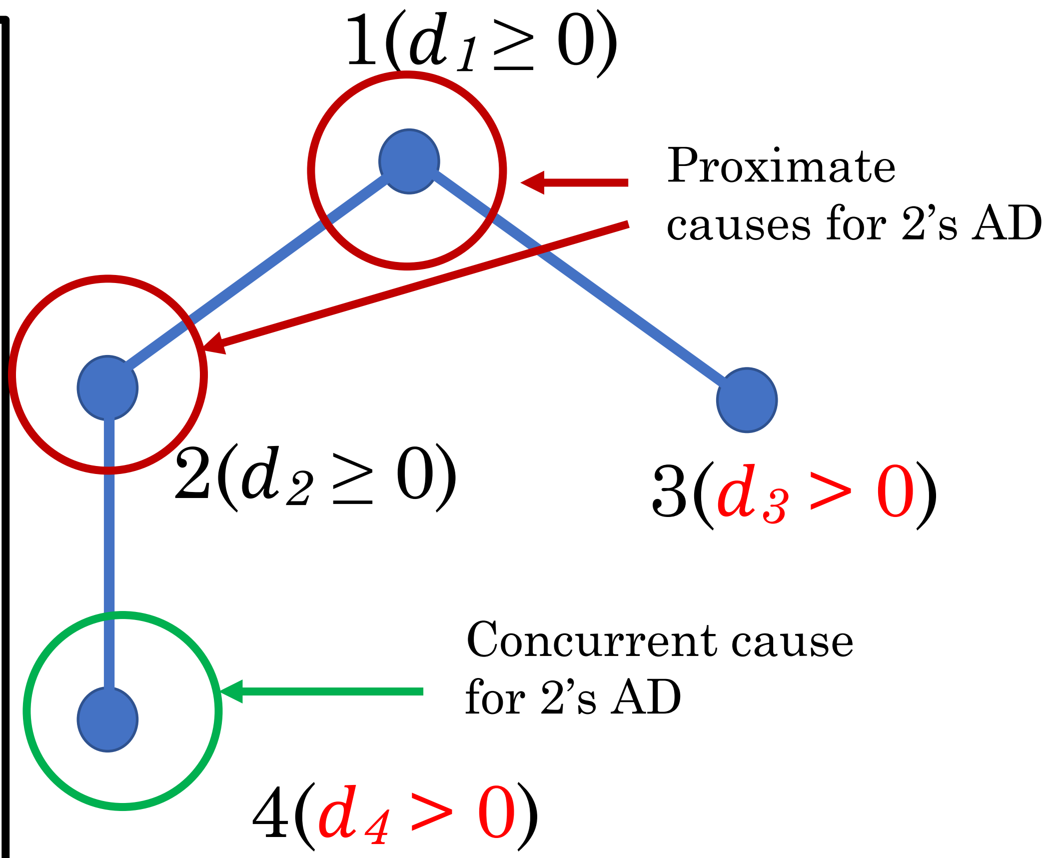
$\geq min\,\{\frac{1}{2}\times$ 4's *AD*, $\frac{1}{2}\times$ 3's *AD* , $\frac{1}{3}\times$ 2's *AD* }

Why 1/3 ? (Here, focus on $i = 2$)

- Suppose that the court determines that legal responsibility for 2's additional damage is limited to both its proximate causes and its concurrent cause.
- Tortfeasor 2 should pay at least $\frac{1}{3}\times$ 2's *AD*.

Why *min* ?

- The court considers a uniform lower bound of payments applied to all additional damages.
- We take the weakest uniform lower bound based on these individual lower bounds.



- 1's additional damage: d_N
- 2's additional damage : $d_2 + d_4$
- 3's additional damage : d_3
- 4's additional damage : d_4

Consistency

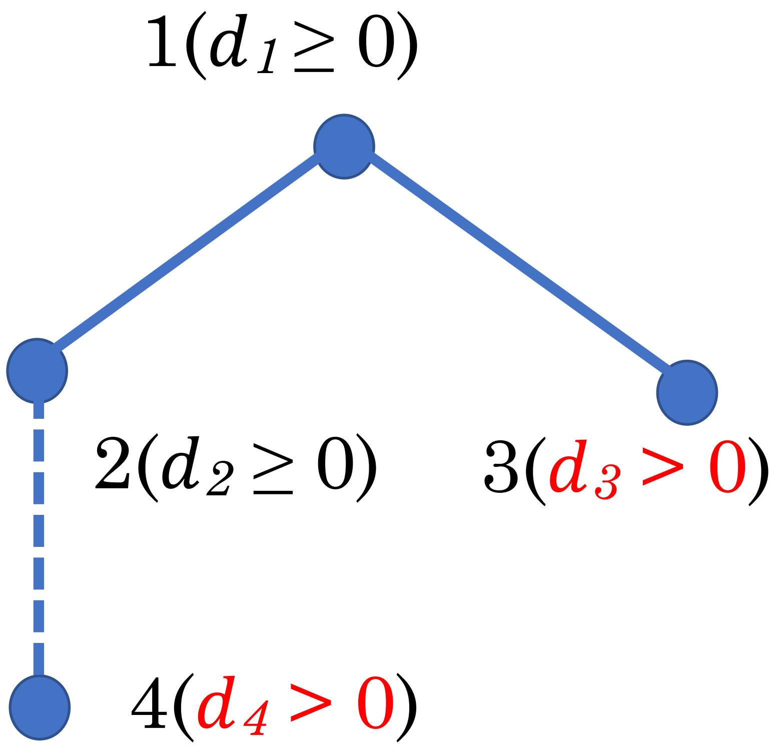
- *One of the founders of Law and Economics, Calabresi (1985)'s idea that gives us the notion of reduced liability problems.*
- A **reduced liability problem w.r.t.** ***x and a leaf (with the last clear chance)***

  $(N', T', d') \in L$
- $N' = \{1,2,3\}$, $T' = \{(1,2)(1,3)\}$.
- d'_i is the modified marginal damage of $i \in N'$ (see Fig.).
- *For* $i = 1,2,3$

  $$\varphi_i(N', T', d') = \varphi_i(N, T, d),$$

where $x_4 = \varphi_4(N, T, d)$.

- As the same way, the reduced liability problem with $N' = \{1,2,4\}$ and $T' = \{(1,2)(2,4)\}$ can be defined.



- 4's payment: x_4
- 2's modified marginal damage (positive):

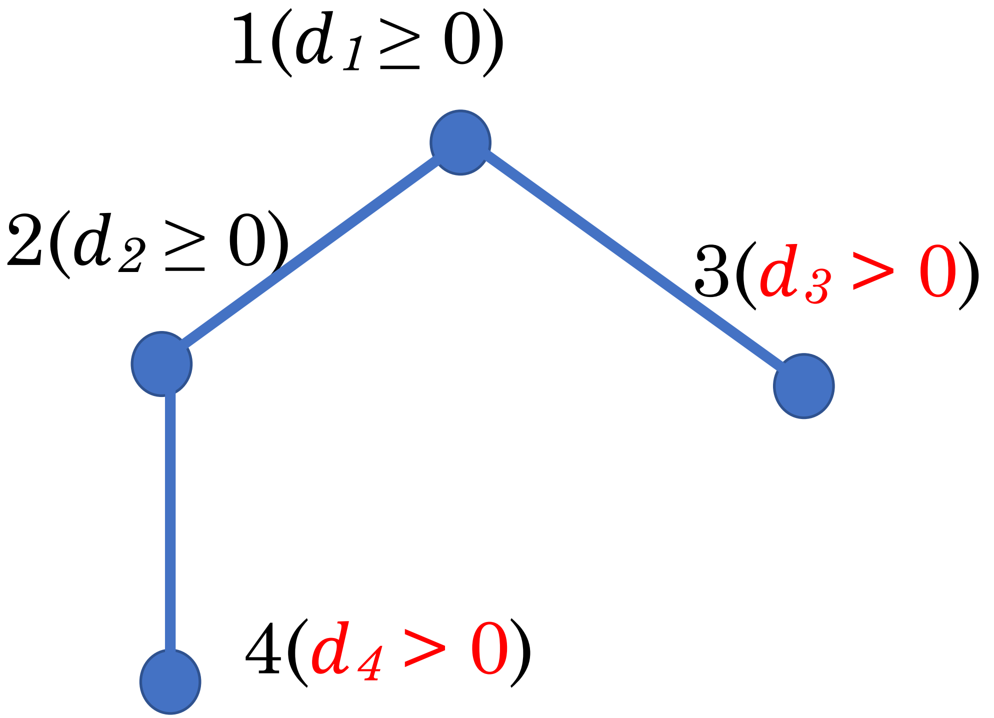
  $$d'_2 = d_2 + d_4 - x_4 > 0$$
- 3's marginal damage : $d'_3 = d_3$
- 1's marginal damage : $d'_1 = d_1$

Weak uniform lower bound and Marginal damage independence

- We introduce a **weak uniform lower bound** by requiring the uniform lower bound only for liability problems with **linear trees** in which the **marginal damage of every predecessor of the leaf is zero**.

- **Marginal damage independence (Ferey and Dehez 2016)** says that a payment of **every tortfeasor who is *not* associated with the proximate causes of tortfeasor *i*'s additional damage**, should **not depend on the change of *i*'s marginal damage**.
- This is because tortfeasor *i's* wrongful act is a component of the proximate causes of his additional damage.

Tort liability games



- **The tort liability game** associated to $(N, T, d) \in \boldsymbol{L}$ is the coalitional game (N, v), where the worth of a coalition $S \subseteq N$ of tortfeasors is the additional damage that the agents in S might cause.
- For every $S \subseteq N$,

$$v(N,T,d)(S) = \sum_{j \in \cup_{i \in S}\{\text{the successors of } i \text{ and } i\}} d_j$$

- This is a cost game faced with a set of tortfeasors.

- $v(N,T,d)(\{2,4\})$: $d_2 + d_4$
- $v(N,T,d)(\{1,4\})$: d_N

- The game introduced here is different from the tort liability game that appeared in Dehez and Ferey (2013), who were the first to introduce a coalitional game for liability problems with **linear trees**.

The Nucleolus/Shapley value based rules

- Nucleolus (Schmeidler 1969)
- A solution that assigns to every game on ***L***, the unique imputation that minimizes lexicographically the dissatisfactions over all vectors in the set of imputations.
- The ***Nucleolus based rule*** is the rule that associates with every liability problem the Nucleolus.

- Shapley value (Shapley 1953)
- A solution that assigns to every game on ***L***, the unique imputation that means that every tortfeasor's payment is a weighted sum of his marginal contributions to all the coalitions *S* containing him.
- The ***Shapley value based rule*** is the rule that associates with every liability problem the Shapley value.

Main results

Theorem

The **Nucleolus based rule** is the only rule satisfying *individual upper bounds*, *uniform lower bound*, and *consistency*.

Theorem

The **Shapley value based rule** is the only rule satisfying *weak uniform lower bound*, *marginal damage independence*, and *consistency*.

Property	Nucleolus based rule	Shapley value based rule
Consistency	+* (used in the axiomatization)	+* (used in the axiomatization)
Individual Upper Bounds	+* (used in the axiomatization)	+ (satisfied)
Uniform Lower Bound	+* (used in the axiomatization)	- (not satisfied)
Weak Uniform Lower Bound	+ (satisfied)	+* (used in the axiomatization)
Marginal Damage Independence	- (not satisfied)	+* (used in the axiomatization)

No rule satisfying CONS, ULB, and MDI.

Relation with the literature

- Law &Economics
- Incentive matters:

  Landes and Posner (1980)

  Shavell (1983)

  Parisi and Singh (2010)
- Normative matters
- Our model **extends the model of Ferey and Dehez (2016)** who introduced liability problems with **linear trees**.
- We focus on **legal notions that are not adopted in Ferey and Dehez (2016),** and therefore we propose **different axioms** than those in Ferey and Dehez (2016).

- Resource allocation problems in the presence of a hierarchical structure
- Dong et al. (2012)
- Ni and Wang (2007)
- Hougaard et al. (2017)
- **Since the tort liability game is a special type of games with a permission structure, this game is applicable to the papers mentioned above.**

- Problems of adjudicating conflicting claims
- Csóka and Herings (2018)
- This model is useful when one wants to model a liability problem where there are **insolvent tortfeasors** and the endowment of each tortfeasor is **endogenously determined by the behavior of the other tortfeasors**.
- Csóka and Herings (2019)
- This model is useful when one wants to consider another liability problem in which there is **a tortfeasor (such as a firm) and multiple plaintiffs**.