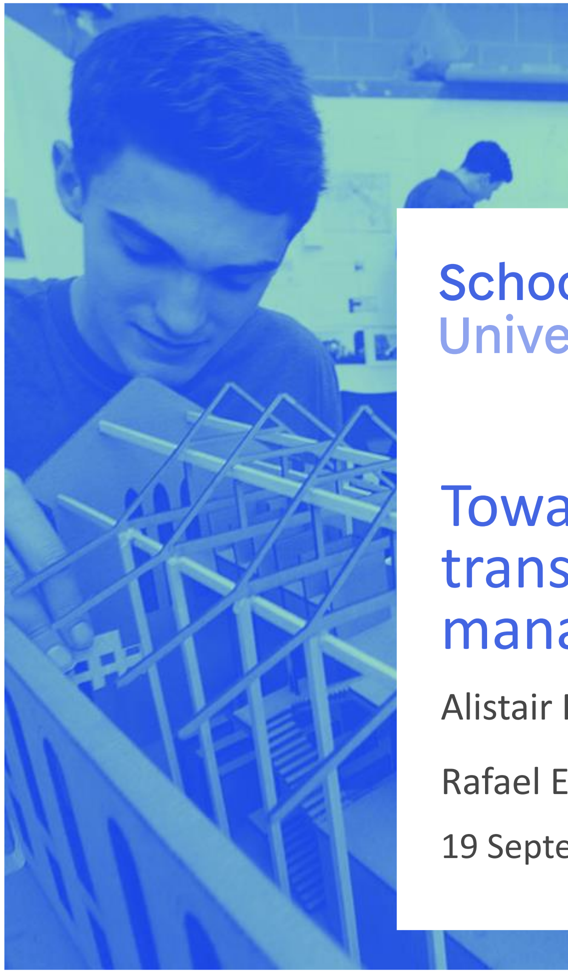

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Towards optimal treaties for transboundary watercourse management

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Outline

- Overview
- Methods & results: Stage 1
- Methods & results: Stage 2
- Conclusions

Overview

- Riparians sharing transboundary watercourse
- Typically interdependent decisions to allocate limitedly available water for competing uses, such as hydroelectric power generation or agriculture
- Decision of one riparian to extract water, depending on how it does so, could unfairly affect water left for other riparians
- Realising this, riparians may agree to enact treaty for joint determination & management of their water allocations

Treaties progressively crucial to stewardship of transboundary watercourses

- But a poorly designed or implemented treaty elevates risk of inadequate or excessive allocations
- Treaty could suffer from fragmentation geographically (e.g. inadvertent exclusion of riparian) or structurally (e.g. deficient rules or principles)
- Hazard of inefficient or inequitable allocations due to faulty configuration or careless operation of treaty is hardly addressed systematically in debate on treaty formation or execution
- To help fill this gap, we propose modelling framework for optimising establishment or performance of transboundary watercourse treaties

Law & economics

- International law either explicit contract (e.g. a treaty) arising from negotiations amongst national bureaucrats or politicians, or implicit contract (e.g. customary international law) describing manifest patterns in behaviour of countries
  - Contract, a master institution of society
  - A perfect contract, in principle, is efficient & complete

- Doctrines of law & economics support design of legal or institutional arrangements enabling market perspective on valuation & allocation of ecosystem services amongst riparians

- Prisoner's Dilemma ("PD") structure describes cooperative behaviour that international law seeks to orchestrate

- Without a third-party enforcer, nations comply with international law only if compliance is in their self-interest (a self-enforcing treaty)

Posner and Sykes (2011), Cooter and Ulen (2014), Rakoff (2016), Macatangay and Rieu-Clarke (2018), Dutta and Radner (2004)

Close link between contract law & justice (principles of transactional justice)

- Justice of the equal exchange, starts with, but does not exclusively focus on, market value (denounces “gross disparity of value” between parties)
- Justice of the wager, supports allocation of risks, symmetrical solutions for alternative outcomes, a fair gamble
- Justice of the term that “fits,” relates to what parties must have meant, reasonable expectations of parties (willingness & ability to be any side)
- Justice as the deserved return, a suitable sequel to chain of events
- Justice as the advantage not taken, pertains to how a party, exploiting situation, could obtain windfall at other party’s expense

Rakoff (2016)

PD

- Profile DD, a dominant strategy Nash equilibrium, is Pareto-inferior to socially optimal profile CC (see Figure 1)
- Society better off if riparians both play C, but each has incentive to play D
- Strong conclusion emerges as long as payoffs satisfy $a_i > b_i > c_i > d_i$ & $2(b_i) > a_i + d_i \; \forall \; i = N, S$ (see Figure 2)

Figure 1 Prisoner's dilemma

		S			
		C		D	
N	C	3	3	1	4
	D	4	1	2	2

Figure 2 General structure

		S			
		C		D	
N	C	b_N	b_S	d_N	a_S
	D	a_N	d_S	c_N	c_S

Overall approach: stages 1 & 2

- Stage 1: develop mixed complementarity problem ("MCP") characterising optimal allocations for each of the riparians
- Stage 2: deploy game theory to demonstrate strategic implications of alternative allocations

Stage 1 (characterisation of optimal allocations)

- Two riparians connected via transboundary watercourse
  - In one riparian, water market
  - In another riparian, electricity market with hydroelectric & thermal generation

- Derive Pareto optimality conditions & prove two propositions
  - Proposition 1: optimal water allocations are function of economic welfare individually accruing to each of the riparians but jointly determined by them
  - Proposition 2: even if there is slack watercourse capacity, riparian has no economic incentive to take more than its Pareto-efficient allocation

Proof of Proposition 1 (sketch)

- At Pareto efficient allocation, marginal rate of substitution ("MRS") between two water uses must be same
  - MRS not only measures inter-riparian value of incremental unit of water, but also reflects value of hydroelectric generation relative to thermal generation
  - Valuations for relief of capacity constraints of either shared watercourse or thermal generation plant are jointly determined by riparians

- Implications
  - If equilibrium is Pareto efficient, no economic basis to deviate from optimal levels of water allocations or thermal generation
  - Otherwise, MRS would differ between riparians, or valuations for relief of any capacity constraints would be inconsistent

Proof of Proposition 2 (sketch)

- If there is slack capacity, given massive amount of water available, shadow value of water zero
  - Implies an incentive to use water for production (optimal allocations positive)
  - Sum of optimal allocations obviously far below extraordinarily high watercourse capacity

- Given Proposition 1, deviating from Pareto optimal levels of output for riparians would cause divergence in their MRS (their valuations for relief of any capacity constraints would be inconsistent)
  - As a consequence, a riparian has no incentive to take more than its optimal allocation just because there is slack
  - In short, more water is not necessarily better

Key inferences in Stage 1 (characterisation of optimal allocations)

- Two propositions
  - Proposition 1: optimal water allocations are function of economic welfare individually accruing to each of the riparians but jointly determined by them
  - Proposition 2: even if there is slack watercourse capacity, riparian has no economic incentive to take more than its Pareto-efficient allocation

- Riparians mutually face a fair set of incentives to ratify a treaty (if there is none) or re-assess its terms (if it already exists)

- Continuously over time or across locations, motivations for treaty ratification or re-assessment repeatedly assessed & efficaciously bring forth gains in social welfare

Stage 2 (implications of alternative allocations)

- Calibration
  - Upstream riparian requiring water for various non-energy purposes
  - Downstream riparian requiring water for hydroelectric generation to supplement its thermal generation or electricity importation

- Simulate behaviour of riparians under two cases
  - Case 1: there is “infinite” amount of water (i.e. abundant enough to prevent watercourse capacity constraint from ever binding)
  - Case 2: amount of water available constrained to be less than sum of their optimal allocations under “infinite” amount of water

Case 1 (unconstrained allocations)

- Determine Pareto optimal water allocations & their efficiency properties (implications of Proposition 1)

- Demonstrate decline in marginal benefit & distortion in MRS condition if more than optimal allocations are taken (implications of Proposition 2)

Case 2 (constrained allocations)

- Reflecting archetypal situation, may lead to strategic game amongst riparians

- If riparians find themselves in a PD
  - Defection a dominant strategy Nash equilibrium but Pareto-inferior to socially optimal cooperation
  - Players have incentive to write treaty in order to obtain benefits from cooperation

But if riparians are not in a PD & if cooperation does not Pareto dominate defection …

- … no incentive to write treaty!

- Given the game, we optimise level of transfers ensuring that cooperation
  - Is dominant strategy equilibrium
  - Is a Nash equilibrium
  - Pareto dominates other profiles

- Transfers, which may be positive or negative, estimated in such a manner that
  - Their sum is less than or equal to zero (i.e. riparians cannot "create money")
  - Resulting payoffs are "as close as possible" to original ones

Key inference in Stage 2 (implications of alternative allocations)

- Enforced transfers, whether positive or negative, supplemental incentives
  - Unprejudiced valuations of physical, commercial, or governance conditions
  - As they naturally evolve, affect incentives for ratifying or re-assessing treaty

- They serve as reasonable mechanisms for implementing monetary damage clause invoked
  - In unlikely event of riparian fraud, misrepresentation, or deceit (i.e. claw-back)
  - Or a non-monetary enticement arranged to enhance prospects of compliance

Conclusions

- Sensible to perform optimisation estimating Pareto-efficient water allocations, even with extraordinarily abundant water

- Optimal treaty facilitates establishment of institutional or procedural mechanisms flexibly perfecting or completing itself (rather than rigid provisions for water allocations)

- Our modelling framework strengthens evidentiary standards for adjudicating disagreements over ambiguity, incompleteness, or imperfection of treaty

Instruments enabling international cooperation (e.g. monetary damages or non-monetary inducements, within a fair setting) …

- … ought to assist parties to new or existing treaty in moving towards self-enforcing agreement

- "Side payments can be monetary but will perhaps more often take the form of concessions on other issues" (Posner and Sykes 2011)

- Use of monetary damages (Guzman 2005)
  - Similar to those in domestic contracts, could enhance prospects of treaty compliance
  - In international agreements, definitely possible, although rare, to provide for monetary damages, such as a zero-sum transfer from one state to another, in order to encourage efficient forms of cooperation

- Consistent with five justices (Rakoff 2016)

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