Chapter 32. Application to Economics: Cost Allocation in India

- Problem and Prior Modeling
- Determining Cost
- Alternative Solutions and Comparison

TUDelft

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Nature of the Problem

- Four Indian regions bear a huge capital outlay for new power generators to supply needed capacity
- The regions are Mysore (now called Karnataka), Kerala, Andhra Pradesh, Tamil Nadu
- Each State Electricity Board plans for self-sufficiency, resulting in inefficient use of joint assets
- There are alternative arrangements possible, resulting in various costs and benefits according to who cooperates
- As policy analysts we want to deliver a fair, equitable and efficient arrangement

How to Evaluate the Costs and Benefits of Cooperation?

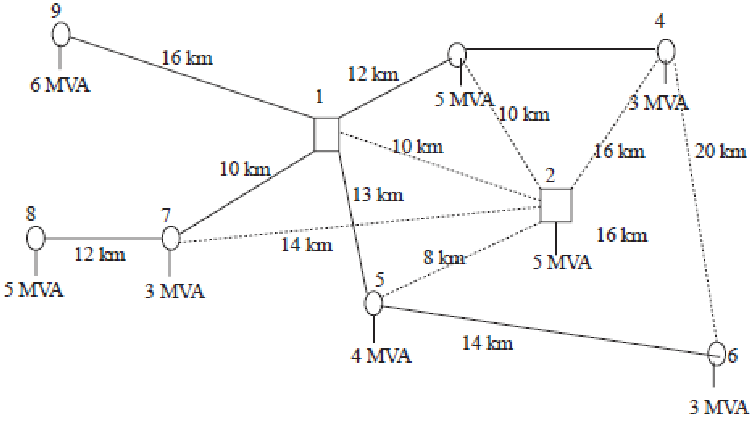
From Node	To Node	Integer Variable	Power flow (MVA)	From Node	To Node	Integer Variable	Power flow (MVA)
1	9	1	6	1	2	0	0
1	7	1	8	3	2	0	0
7	8	1	5	2	4	0	0
1	5	1	7	2	6	0	0
1	3	1	8	2	5	0	0
3	4	1	3	2	7	0	0
5	6	1	3	4	6	0	0

Mixed Integer Linear Programming

Calculate the optimum investment and routing of power under various scenarios of cooperation

Decision variables are routing as well as location of the physical plant

Computer optimization makes the vast number of possibilities a tractable problem



Example from (Turkay, 1998)

Cost Calculations

	Costs incurred in			
Coalition structure	T	A	K	Total
$\{T\}\{A\}\{K\}$	533	187	86	806
$\{T,K\}\{A\}$	260	187	242	689
$\{A,K\}\{T\}$	533	48	148	729
$\{T,A\}\{K\}$	552	147	86	785
$\{T,A,K\}$	301	101	251	653

T = Tamil Nadu A = Andhra Pradesh K = Kerala-Mysore

Units are 10 million rupees, value in 1974.

Table from Game Theory and Strategy (Straffin 1993) p.209

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The Savings Game

$$v(T) = v(A) = v(K) = 0$$

$$v(TK) = 533 + 86 - 502 = 117$$

$$v(AK) = 187 + 86 - 196 = 77$$

$$v(TA) = 533 + 187 - 699 = 21$$

$$v(TAK) = 533 + 187 + 86 - 653 = 153.$$

Individual Costs

Group Costs

Prospective Savings

Table adapted from Game Theory and Strategy (Straffin 1993) p.210

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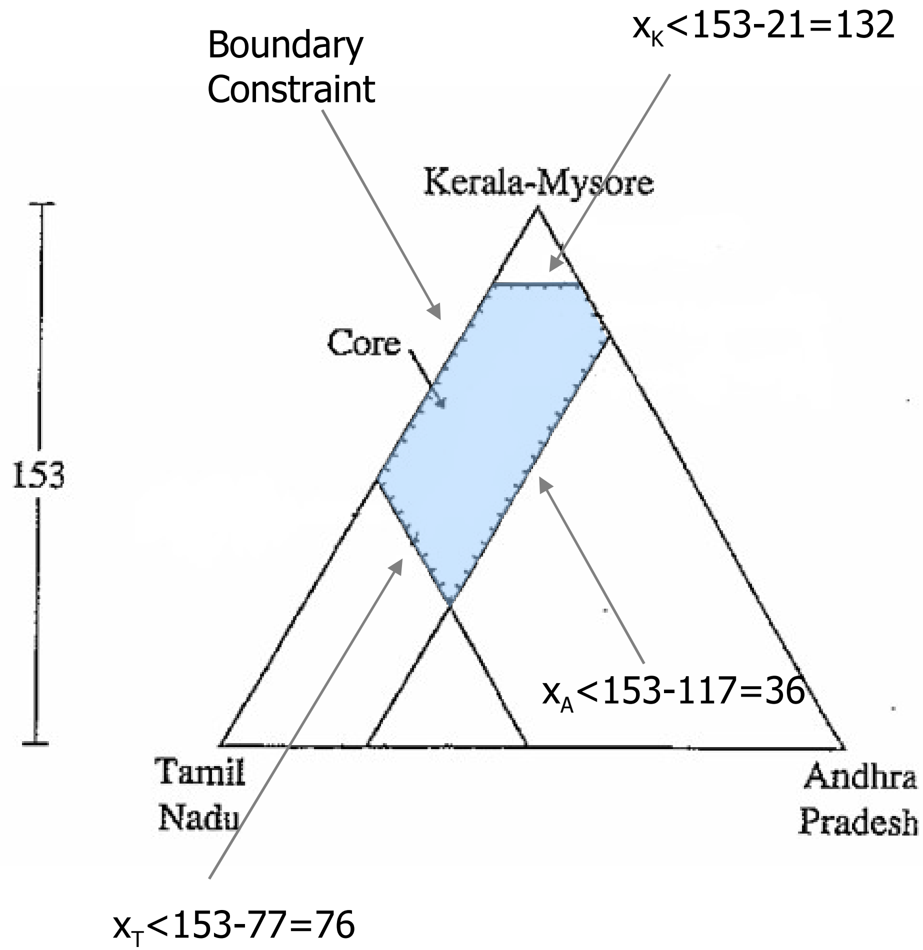
A Variety of Cooperative Concepts. Which to Choose?

- Why Use the **Core?** We believe that we should pursue a solution in the best interests of all parties.
- And, because we want a single value solution:
  - Why Use the **Shapley Value**? We hope to mediate the situation based on principles of fairness.
  - Why Use the **Nucleolus**? We hope to maximize general satisfaction with the solution.
  - Why Use the **Gately Point**? We know that Kerala-Mysore should be placated for their strategic assets.

Strategic Assets: Hydroelectric Power in Kerala-Mysore

Nagarjuna Sagar Dam in Andhra Pradesh. Picture by Sumanthk (public domain).

Finding the Core

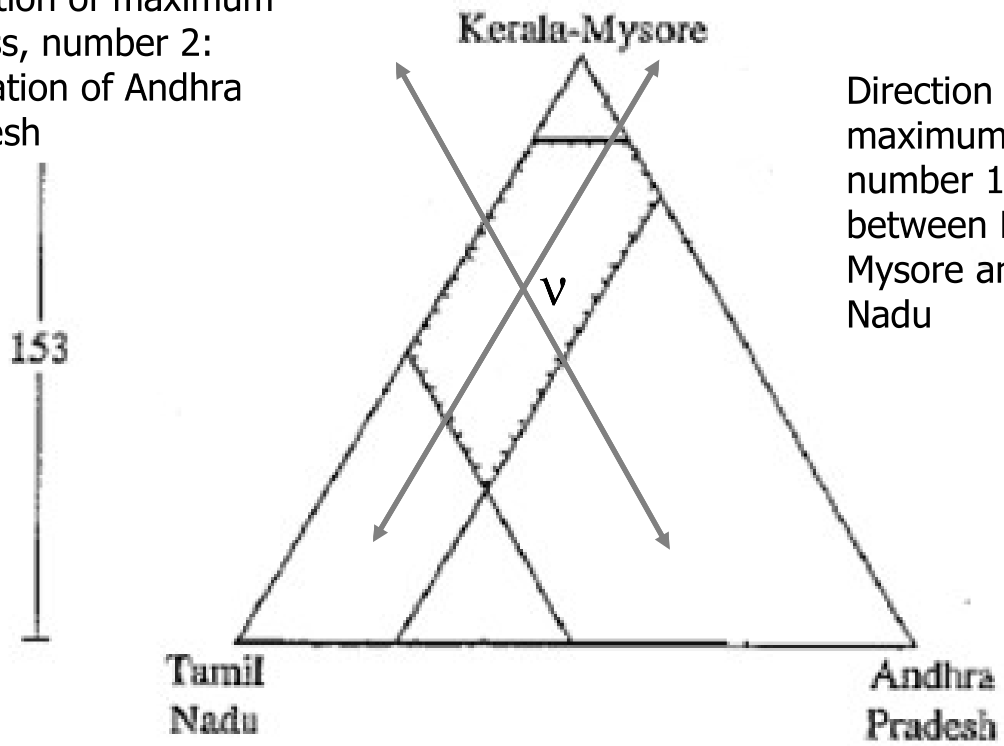


Players A and T can secure at least 21 from cooperation
Thus K can secure no more than 132

Diagram adapted from Game Theory and Strategy (Straffin 1993) p.210

Solving for the Nucleolus

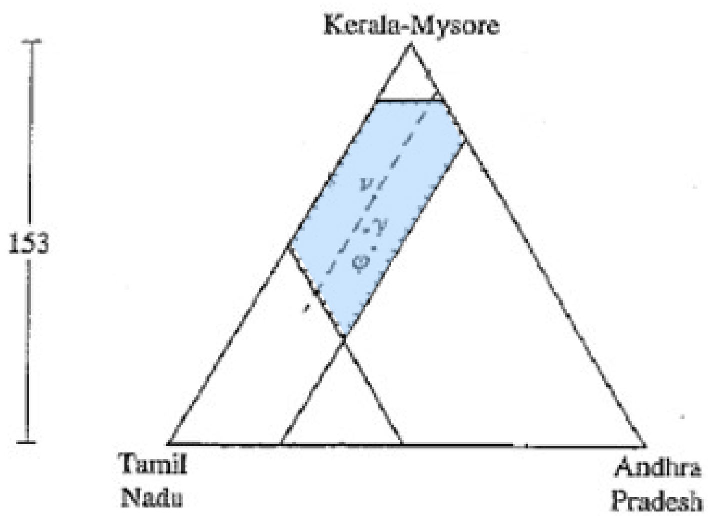
Direction of maximum excess, number 2: Allocation of Andhra Pradesh



Direction of maximum excess, number 1: Allocation between Kerala-Mysore and Tamil Nadu

Diagram adapted from Game Theory and Strategy (Straffin 1993) p.210

Graphical Comparison of Solutions



- Proportional to Power Use
- Incurred Cost

This is the cost game.

In recognition of the strategic advantages of Kerala-Mysore we ask them to pay less.

Otherwise, quite comparable results!

If we were to use other non-cooperative measures, the solution would be way outside of the core.

Diagram adapted from Game Theory and Strategy (Straffin 1993) p.210

Gately's More Recent Work

- OPEC expansion and consequent oil pricing
- Any OPEC nations able to expand export will have strong incentives to do so
- OPEC may not be able to maintain its level of export
- Reasonable assumptions about price responsiveness and non-OPEC supply means that real oil prices will not be sustainably much higher (2006)
- OPEC under investing in capacity for its own sake, and that of the world.