The Netherlands Research School for Transport, Infrastructure and Logistics
TRAIL

A Game Theoretical Approach to Analysis of Value Capturing Implementation

BACKGROUND

Value capturing have been considered as a promising additional way of funding infrastructure development. We define value capturing as a process by which all or a portion of the increments in land and property values that result from specific public improvements or any other actions attributed to a public effort are recouped by the public sector and used for public purposes. However, its implementation could be problematic because property owners usually have the legal right to enjoy the increment values of their properties. A possible approach to value capturing might be to allow the stakeholders to start a bargaining process to distribute the increment values. Inevitably, real-life bargaining processes are often muddy and obscure.

This study presents the analysis of the bargaining process in the implementation of value capturing based on concepts drawn from cooperative game theory in characteristic function form. The institutional setting of location development related to infrastructure development in the Netherlands is used to provide an empirical context to the analysis. Our study shows that game theoretical approach offers a useful method to conceptualise relations between different stakeholders and analysing bargaining and negotiation process to reach an agreement about the efficient and fair allocation of the increment land values.

CONCEPTUAL FRAMEWORK

- The implementation of value capturing = the result of an agreement among several stakeholders: the infrastructure developer (ID) and the landholding commercial developers (LD),
- The agreement to contribute is a form of cooperation: a coalition
- The aim of the analysis: to observe the coalition formation and the distribution of the increment property values. The part of the increment value that goes to the ID = the expected value to be captured in the value capturing.
- 3 Hypothetical situations with 3 players (1 ID and 2 LDs):
  1. ID will build the infrastructure only if it can form a coalition with LD. LD will not be able to build its land without infrastructure.
  2. ID will build the infrastructure only if it can form a coalition with LD. LDs are able to develop their land without infrastructure.
  3. ID is able to build the infrastructure without making any coalition with LD but a coalition would provide more benefit to ID.

THE MODEL: Cooperative Game in Characteristic Function Form

For N = {1, 2, 3}; 1:ID, 2:LD1, 3:LD2

- LD's expected revenue = x
- Additional value caused by infrastructure development = δx

The characteristic function for:

Situation 1

$v(1) = v(2) = v(3) = 0;$
$v(12) = v(13) = x + \delta x$
$v(23) = 0;$
$v(123) = 2(x + \delta x)$

Situation 2

$v(1) = 0;$
$v(2) = v(3) = x;$
$v(12) = v(13) = x + \delta x$
$v(23) = 2x;$
$v(123) = 2(x + \delta x)$

Situation 3

$v(1) =$
$v(2) = v(3) = x + \delta x;$
$v(12) = v(13) = x + \delta x$
$v(23) = 2(x + \delta x);$
$v(123) = 2(x + \delta x)$

SOLUTION CONCEPTS: The Core & Shapley value

- The core (Gillies, 1959): the set of feasible allocations of payoff in a coalition that cannot be improved upon by any other feasible coalition. The core is the collection of payoff allocations $x \in \mathbf{R}^N$ that satisfying
  - Efficiency: $\sum x_i = v(N)$,
  - Coalitional rationality: $\sum x_i \geq v(C)$ for all subsets (coalitions) $C \subseteq N$.
- Shapley Value (Shapley, 1953):
  For N=3, the Shapley value (Φ) can be formulated as follows
  $\Phi i = 1/3[v(ijk)-v(jk)] + 1/6[v(ij)-v(j)]+1/6[v(ik)-v(k)]+1/3[v(i)-v(\emptyset)]$

Situation 1

- The Core solution:  $\{(0, (x + \delta x), (x + \delta x)); ((x + \delta x), (x + \delta x), 0); ((x + \delta x), 0, (x + \delta x))\}$
- Shapley value solution: $\Phi_1 = x + \delta x; \Phi_2 = \Phi_3 = ½(x + \delta x)$

Situation 2

- The Core solution:  $\{(0, (x + \delta x), (x + \delta x)); ((\delta x), (x + \delta x), x); ((\delta x), x, (x + \delta x))\}$
- Shapley value solution: $\Phi_1 = \delta x; \Phi_2 = \Phi_3 = (x + ½\, \delta x)$

Situation 3

- The Core solution:  $\{(0, (x + \delta x), (x + \delta x))\}$
- Shapley value solution: $\Phi_1 = 0; \Phi_2 = \Phi_3 = (x + \delta x)$

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