

No.75

Design and Evaluation of the Joint Venture Formation in EPC Projects

December 8, 2018

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Overview of the Presentation

- ① Background & Objectives
- ② Related work
- ③ Design Method for Competitive Joint Venture Formation
- ④ Mathematical Model in Design Method
- ⑤ Evaluation
- ⑥ Conclusions

EPC (Engineering-Procurement-Construction) Project

- Contractors **design and build unique products** based on the client requirements.
- Contractor has **a solo responsibility** for the project as **a lump-sum contract**.

Typical Examples of EPC Project: Construction, Civil engineering, Plant Engineering, Information System Development, etc.

EPC contractors have been suffered
unstable business results, so far.



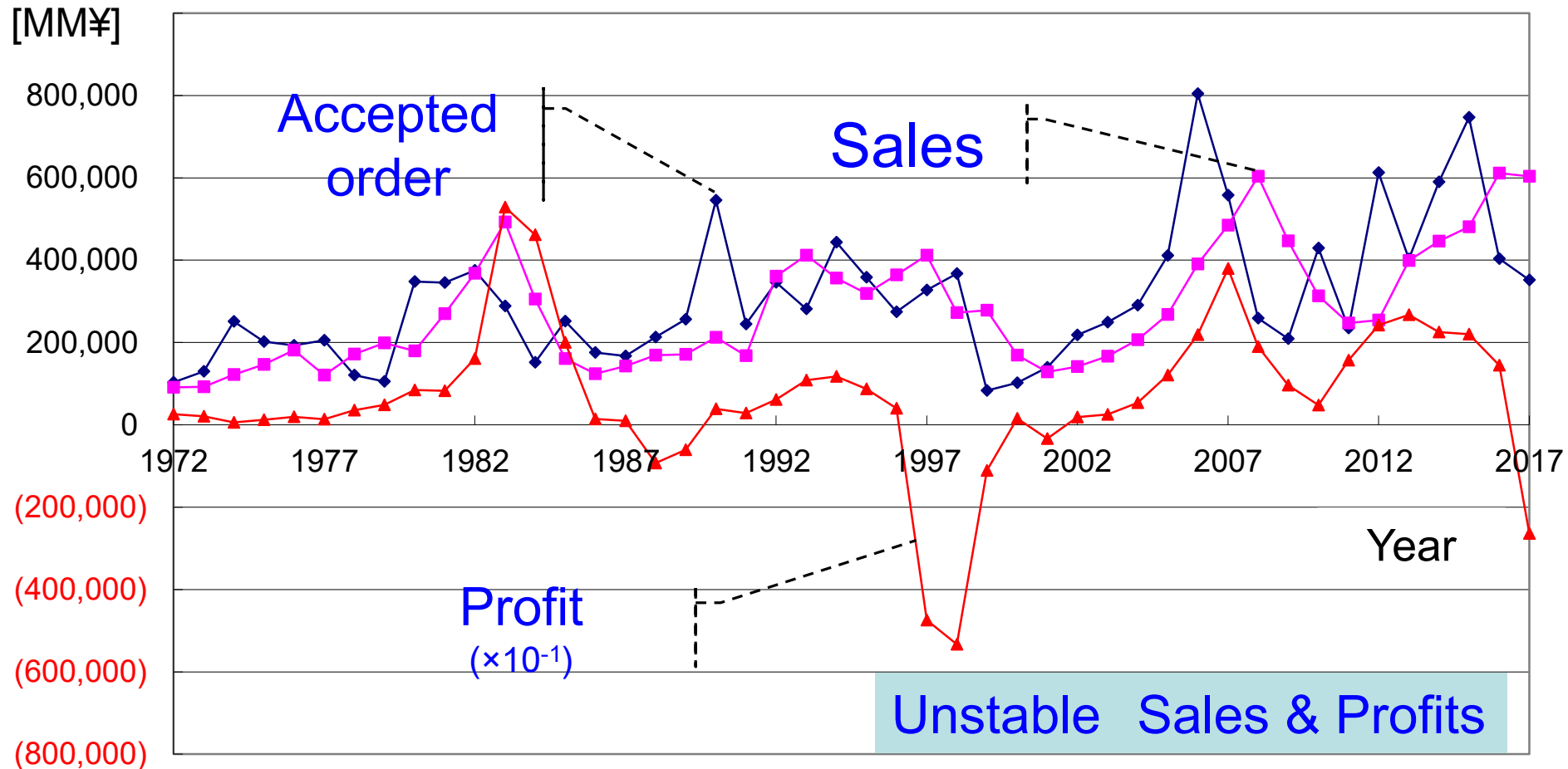
Contractors' unstable business results
would also have
harmful effects on client's business.

- 
- Additional cost
 - Delay of project delivery

Background

About EPC Project


Example <Financial results of a world class contractor>



In EPC, contractor's business performance is highly affected by the market & competitors' conditions.
Stable profit is critical for any contractor to improve sustainability.

Why so unstable?

Risks of cost & time affect profitability, especially, in **complex & large-scale EPC** projects.



“Reduce risks of project ” is critical for the contractor to gain stable profit.



One solution:

The joint venture contract

It has become more common among EPC contractors.

More than one contractor works on a project in the joint venture.

Why Joint venture can reduce risks:

Each partner in joint venture **needs not carry out all the works** in the project **by sharing works within partners.**

Each partner **only need to carry out the works having specialty.**



Risks of cost & time could **be reduced by the complementary effects** within joint venture partners.

However,

Partners in the joint venture encounter **many challenges to gain advantages** by forming a joint venture.

<Examples>

- ✓ Increased managerial costs,
- ✓ Hard negotiations of profit & risk sharing among partners, and so on,



A method to design **a competitive joint venture formation** is necessary.

Research Objectives

Based on the background;

Develop **a method to design a competitive joint venture formation;**

Reduce project cost and deficit risks,
by maximizing the complementary effects
within joint venture partners.



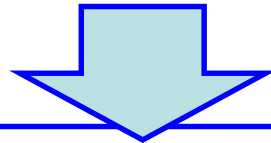
Related work

Related work

Most studies on joint ventures have focused on complementarity in **repetitive businesses**,

Literature focusing on **project-based business has been limited** so far.

Especially, **issues for organizing competitive joint venture formation in EPC projects** have not been studied well by either industry and academia, although expectations for joint venture contracts have increased among EPC contractors.



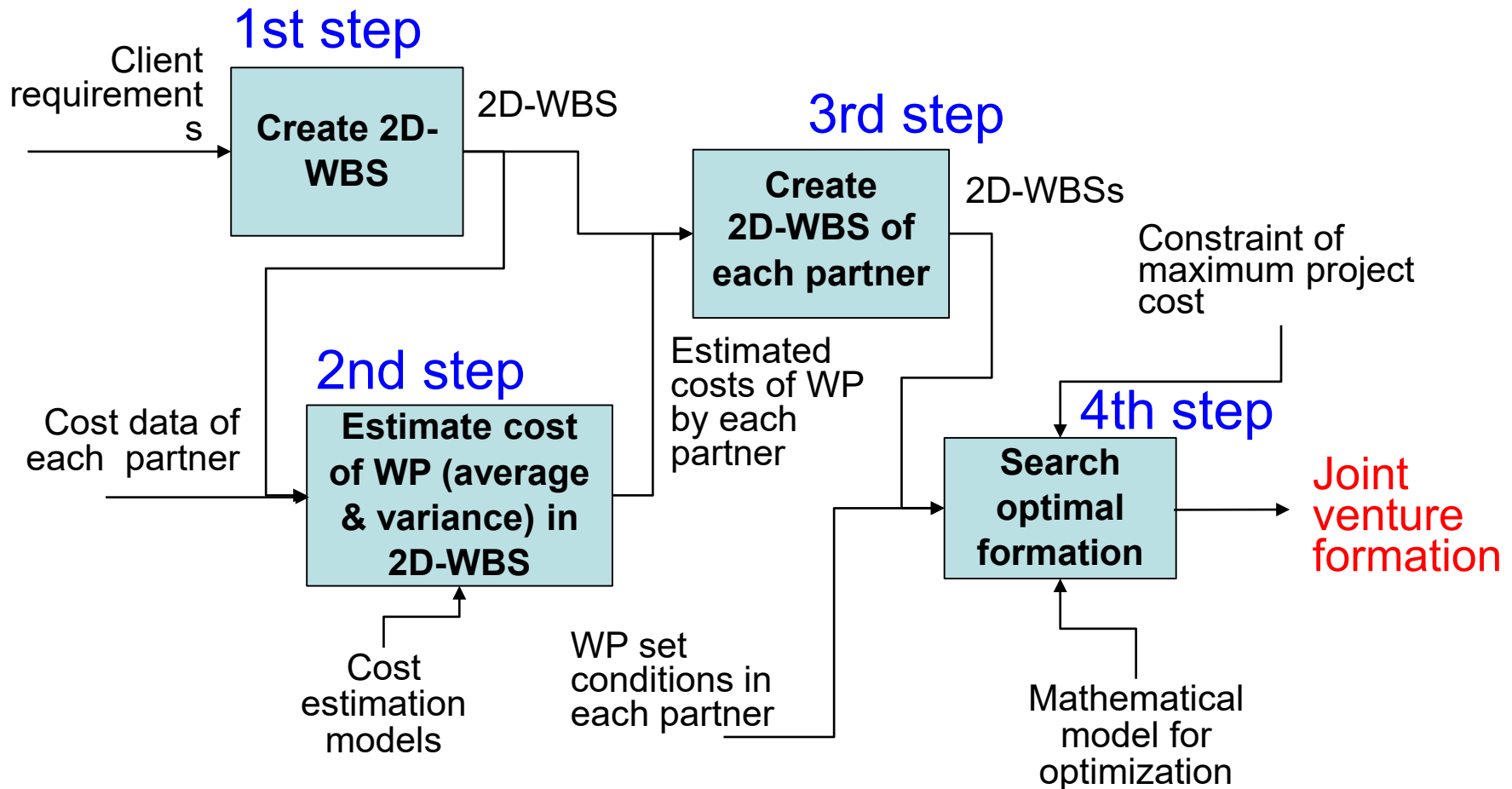
This paper focuses on **the design of joint venture formation in EPC projects**
as **a new area of joint venture studies**.



Overview of design method

Overview of design method

The design method consists of four steps.



Overview of design method

1st Step:

Creates a **2D-WBS (Work Breakdown structure)** based on **the project scope** determined by the client requirements,

Indicates the work process in the EPC project, such as design, procurement, and construction processes.

Shows the work breakdown to deliver the results of the project.

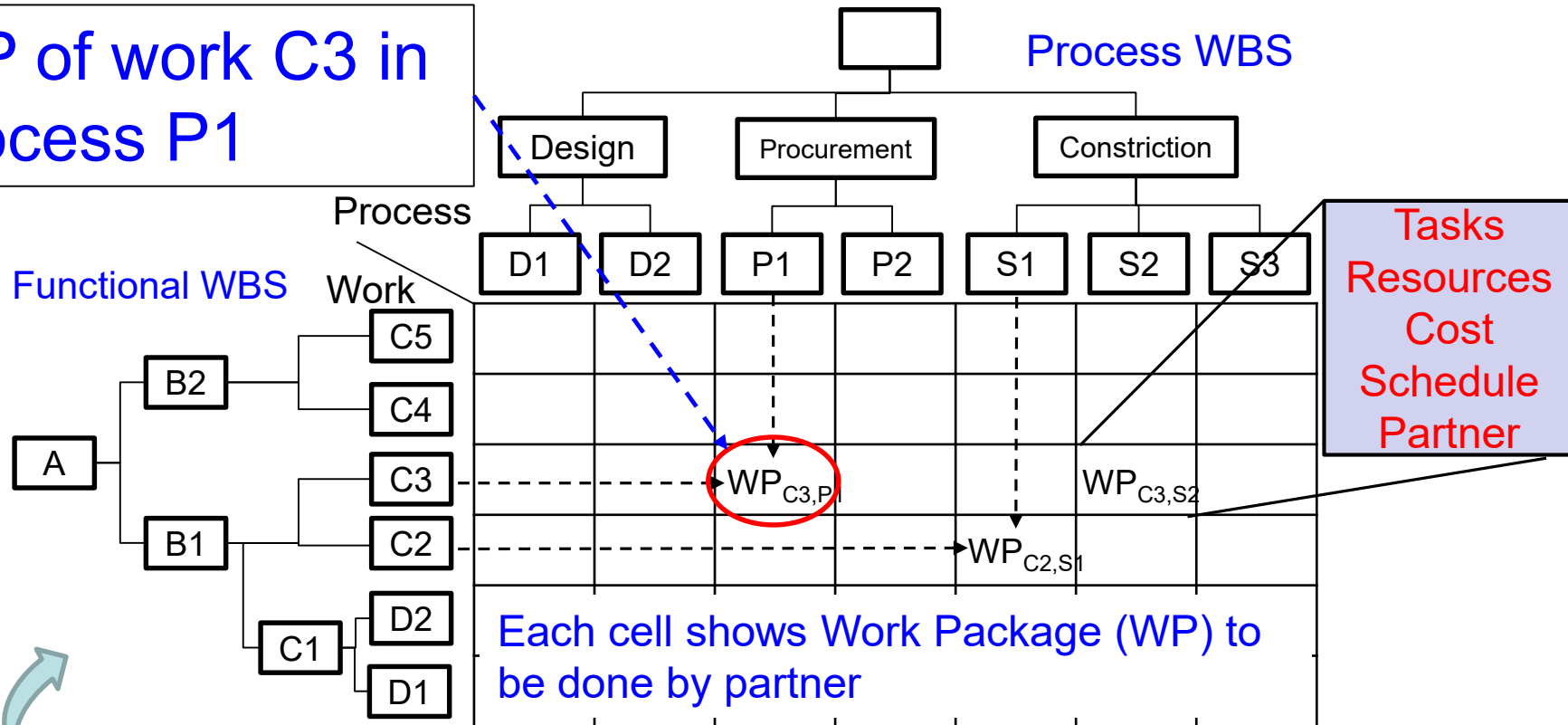
The 2D-WBS:

- Consists of a **process WBS** and **functional WBS**,
- Shows the association between the **WPs** of the project and **the potential partners** carrying out the WPs.

Two-Dimensional Work Breakdown Structure (2D-WBS).

The 2D-WBS is used as a platform of joint venture design in Steps 2 to 4.

WP of work C3 in process P1



Final deliverable is A,
and the works to deliver A is broken down as C2 via C5,
and D1 and D2.

Overview of design method

2nd Step:

Cost and MH data of each WP in the 2D-WBS is estimated by each partner.

- Cost estimation model & cost data would be different for each partner,



Estimated costs & cost estimation accuracy can be different for each partner. → AACE cost model

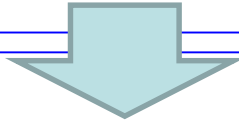
- Uses the data of the **cost estimation accuracy** to **evaluate the project deficit risk**.

Cost estimation accuracy is defined as the percentage of deviation from the actual cost.

Overview of design method

3rd Step:

2D-WBS of each partner is created by putting the cost and MH data of WPs into the 2D-WBS. Total N 2D-WBSs are created if the number of partners is N .



4th Step:

Joint venture formation is searched based on the project data in the 2D-WBSs by using the mathematical model.

The model finds the combinations of WPs and partners who carry out the WPs so that the sum of cost variances of WPs is minimized under the constraint of the maximum project cost like a portfolio optimization problem.

Mathematical Model in Detail

Minimize

$$\sum_{n=1}^N \sum_{w=1}^W \sum_{p=1}^P a_{w,p}^n dcv_{w,p}^n \quad (1)$$

Minimizes the sum of the variance of WPs' costs.

Subject to

$$a_{w,p}^n = \{0, 1\} \quad (2)$$

Decision variable of the formation of JV.

Constraints of project costs.

$$\sum_{n=1}^N a_{w,p}^n = 1 \quad (w = 1 \sim W, p = 1 \sim P) \quad (3)$$

$$\sum_{n=1}^N \sum_{w=1}^W \sum_{p=1}^P a_{w,p}^n dc_{w,p}^n + \sum_{n=1}^N \left(\sum_{w=1}^W \sum_{p=1}^P a_{w,p}^n idc_{w,p}^n \right)^{sc} < tco \quad (4)$$

Constraints of MH of each partner.

$$\sum_{w=1}^W \sum_{p=1}^P a_{w,p}^n mh_{w,p}^n \leq HM^n \quad (n = 1 \sim N) \quad (5)$$

If WP_{w,p} and WP_{w',p'} must be carried out by the single

A set of WPs each partner intends to carry out.

partner n for all w and p.

$$a_{w,p}^n = a_{w',p'}^n \quad (n = 1 \sim N)$$

(6)



Numerical Examples

Numerical Examples


<Objectives>

Evaluate the effectiveness of the design method of joint venture formation by examining the expected profits of EPC projects,

with the result of improved cost estimation accuracy and/or the reduced project cost .

<Evaluation method>

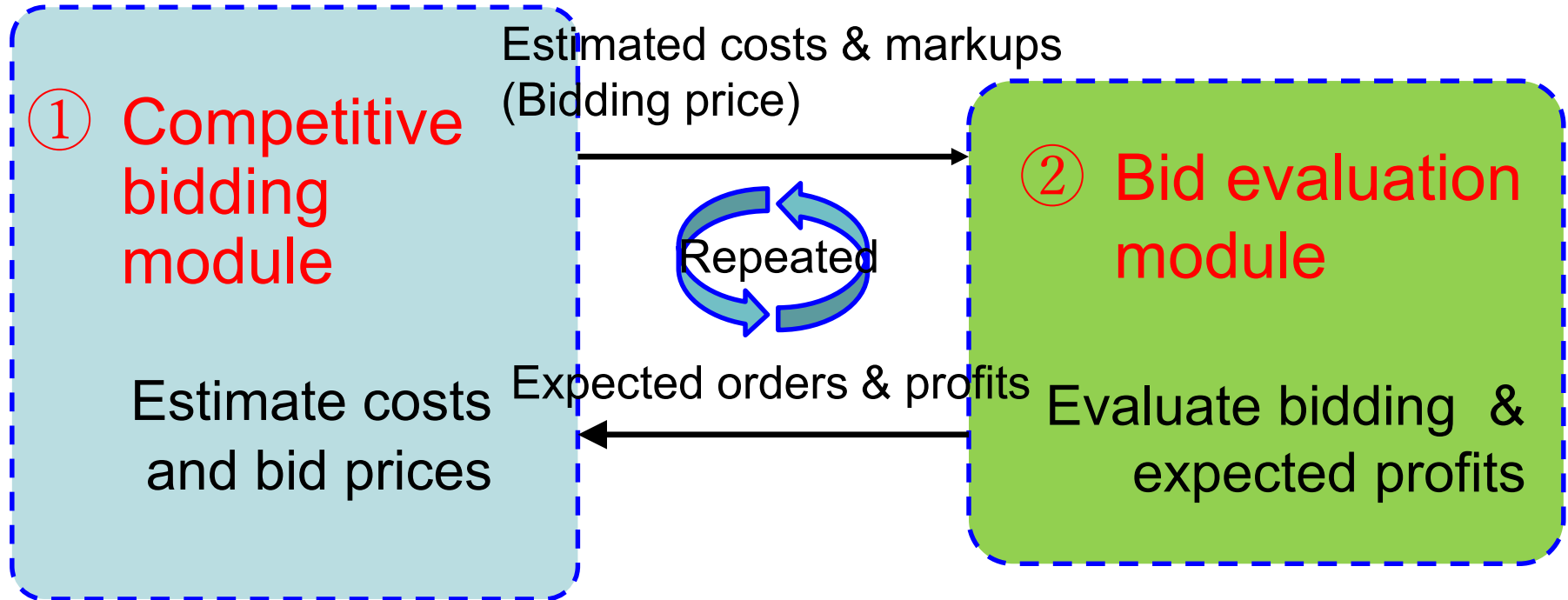
Simulation model of the competitive bidding is used for evaluation.



Simulation Model for Evaluating Joint Venture Formation

Simulation Model --- Two modules

Consists of two modules.



Search the bidding price maximizes the expected profits.

Bidding price = Estimated cost + Markup.



Design of Simulation Experiments

Simulation scenarios

S0 (Base scenario): No joint ventures.

S1: Reduced project cost by JV.

S2: Improved cost estimation accuracy & the reduced project cost by JV.

Scenario	Organization	Cost estimation accuracy	Cost reduction
S0	One's own company Competitors	+/-5%	none
S1	Joint venture	+/-5%	0~5% of S0 cost
	Competitors	+/-5%	none
S2	Joint venture	+/-3%	0~5% of S0 cost
	Competitors	+/-5%	none

Cost estimation accuracy = the percentage representation of the coefficient of variance, such as 5% of the actual cost. It is obtained by dividing the standard deviation of the estimated cost by the actual cost. Namely, a lower deviation means higher estimation accuracy.

Simulation data

(MM: Million)

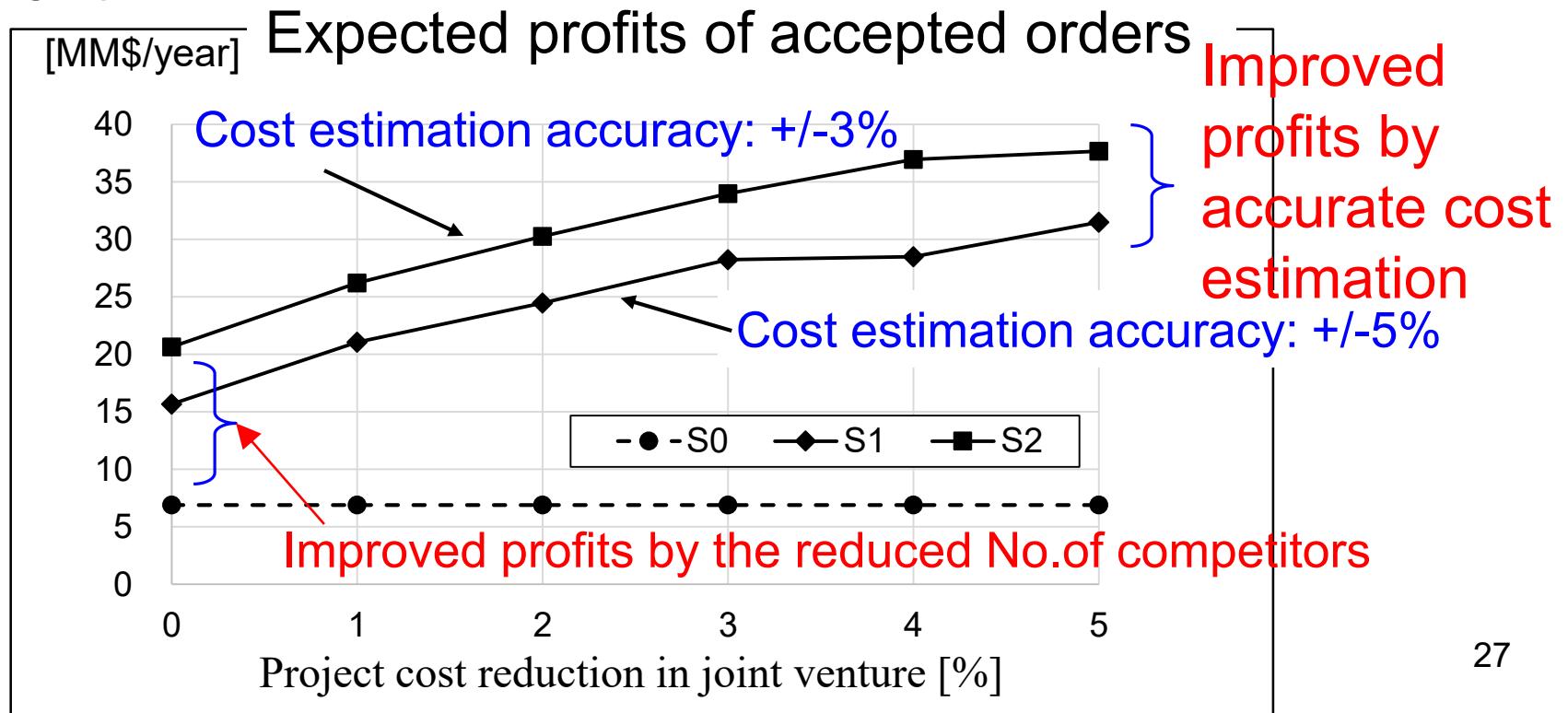
Number of simulation runs SR		5
Number of simulation years N		5
Number of competitors	S0	5
	S1 and S2	4
Number of orders in each simulation year		10
Probability function of project cost		Normal distribution
Markup in competitor j : rmk_i^j		Random variable between 9~11%
Actual project cost		100 [MM\$/project]
Target volume of accepted orders in each simulation year	Joint venture	500 [MM\$/year]
	one's own company	250 [MM\$/year]



Results of Simulation Experiments

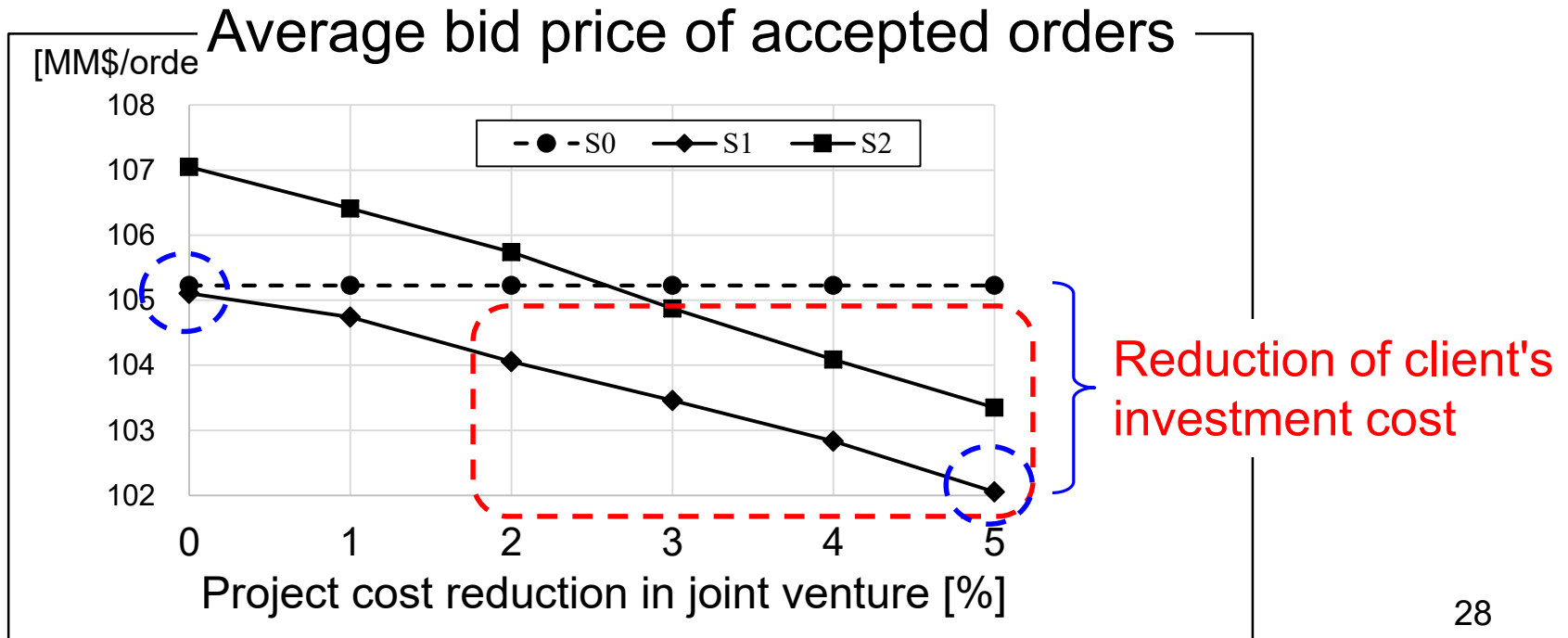
Results of Simulation Experiments

- The expected profits in the joint venture increases according to the reduction of the project cost
- The improved cost estimation accuracy by the effect of joint venture formation increases the expected profit.



Results of Simulation Experiments

- The average **bid prices** in the joint venture **slightly decreased** according to the project cost reduction.
- The joint venture can **improve contractors' profits** as well as **reduce the investment costs of clients**.





Conclusions

Conclusions

- ① **Develop a design method & a mathematical model** to identify a joint venture formation.
 - ✓ Minimizes the cost estimation errors associated with the deficit risk of projects under the constraints on the maximum expected project costs and MH.
 - ✓ Consider the complementary effects of the joint venture and the managerial cost among contractors within the formation.
- ② **Propose the 2D-WBS** as a platform to indicate project data of each partner organizing the joint venture formation.

Conclusions



③ Findings via simulation experiments.

- ✓ Joint venture can reduce deficit risks and improve the expected profits
- ✓ Joint venture can also reduce client's investment cost

Conclusions

Further research

① **The design method** should consider more facets of the joint venture,

Such as, knowledge creation, the presence of competition between joint venture partners, and so on, to evaluate the diverse aspects of joint ventures.

② **The mathematical model** should be expanded so that it can consider the bid conditions and bid strategy of each competitor,

③ **In the simulation model** of the competitive bidding, the bid performance of each competitors should be evaluated not as a set of competitors.



**Thank you very much
for your kind attention.**

This work was supported by JSPS KAKENHI Grant Number
16K01252.