4.4 Bidding Strategies for Shapley Value Profit Sharing

Shapley Value Profit Sharing

Profit Sharing Rule:

Calculating the Shapley Value

$$Shapley\ Value_{\ i} = \sum_{S, i \in S} \frac{(|S| - 1)! * (|N| - |S|)!}{|N|!} * [g(S) - g(S \backslash \mathrm{i})]$$

Where:

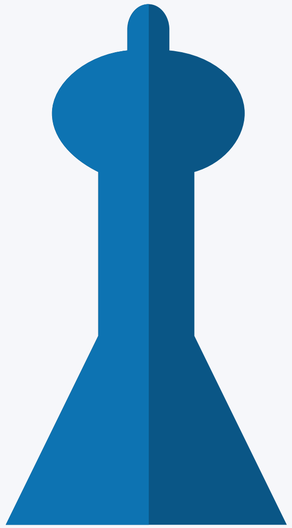
N = Grand Coalition of Carriers
S = Subset of Grand Coalition
g(S) = Collaboration Gain of Coalition S

See [11]

Strategies

Conspiring Bidder Strategies

INPUT_MAX
Increase price of Input Bid

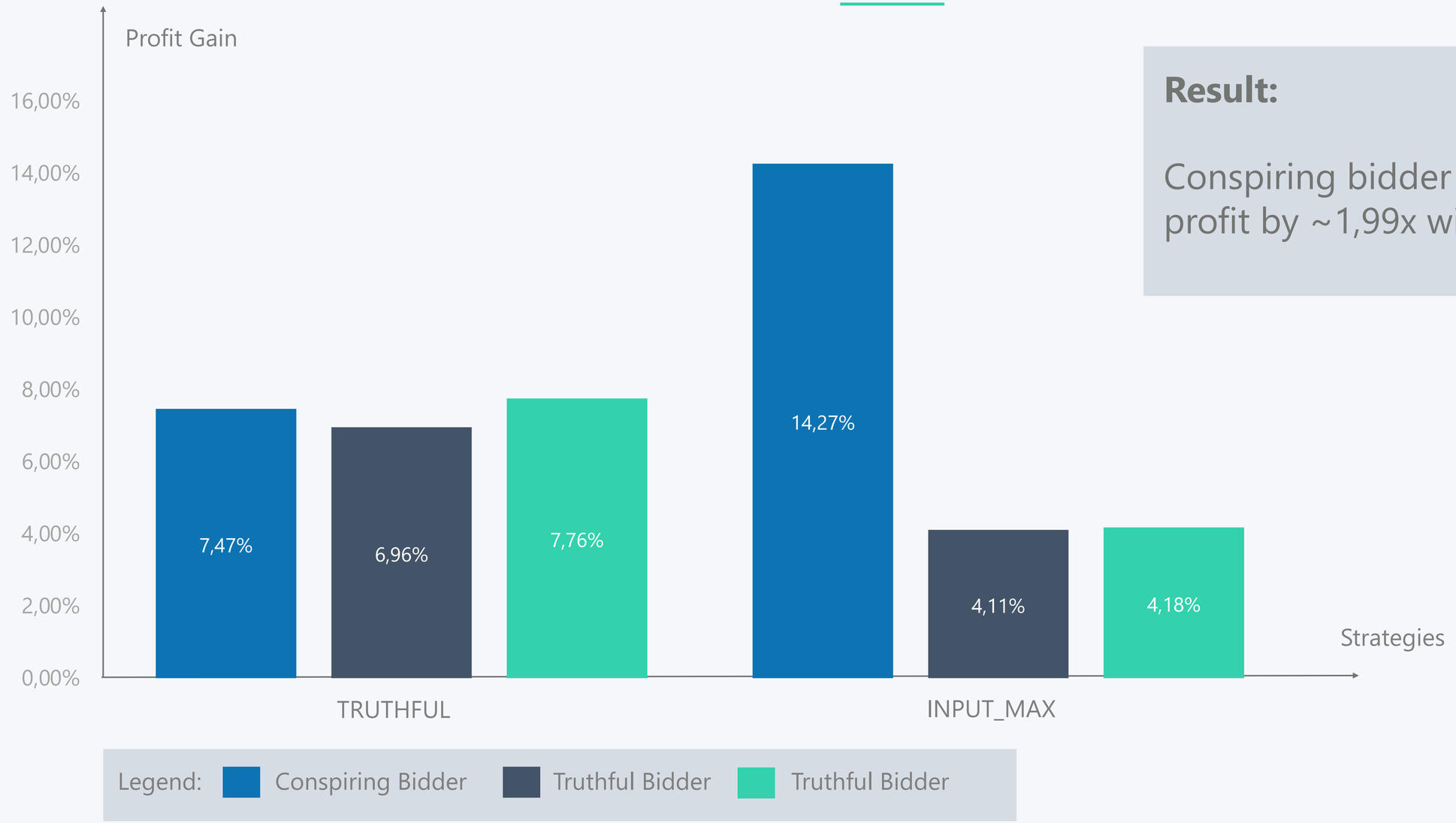


Strategic Bidder Strategies

INPUT_MANIPULATION
Overbid/Underbid on the Input Bid

BID_MANIPULATION_REL
Overbid/Underbid on all bids with a relative margin

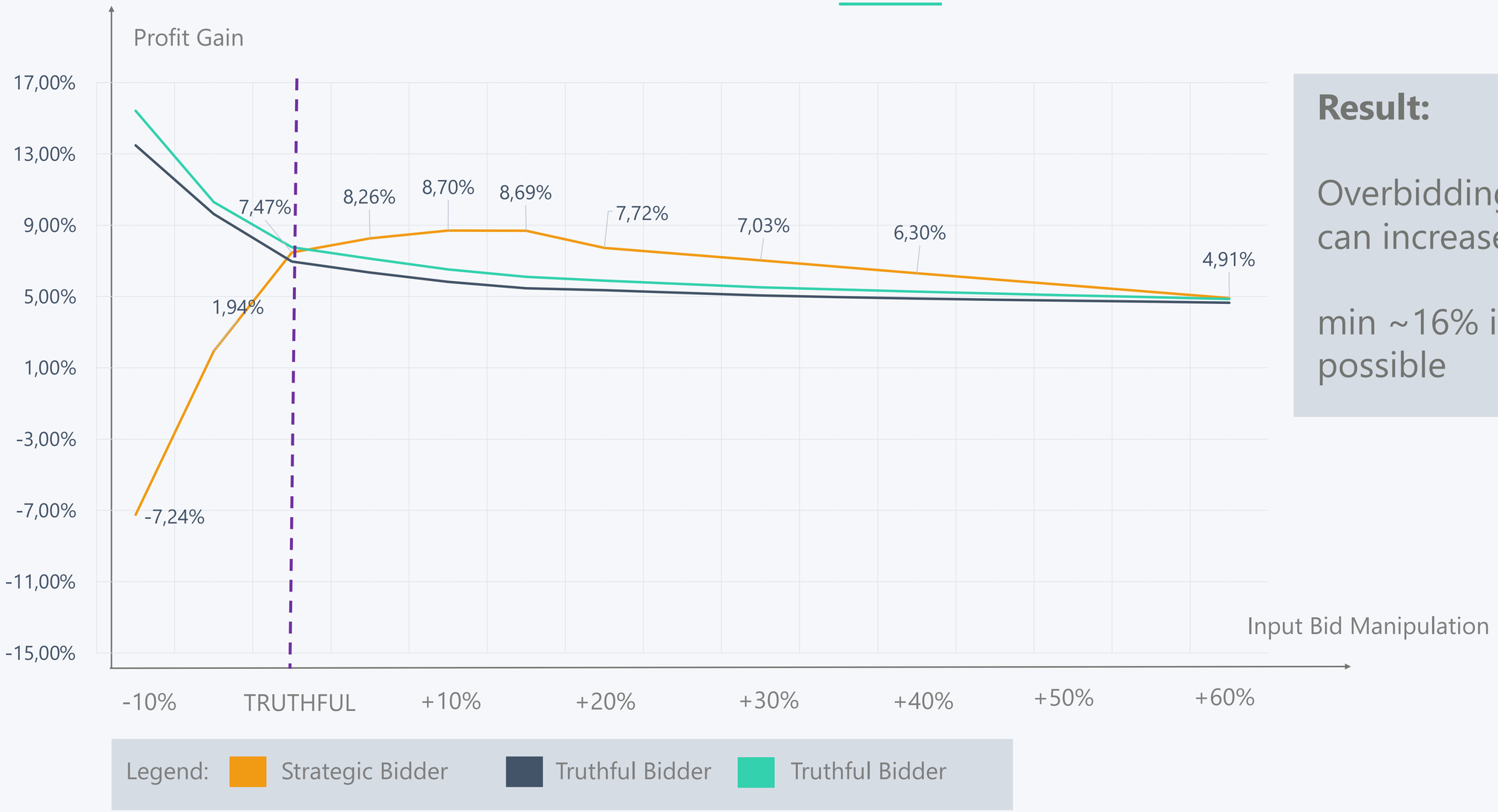
Test Results for Conspiring Bidder



Result:

Conspiring bidder can increase her profit by ~1,99x with INPUT_MAX

Test Results for Strategic Bidder

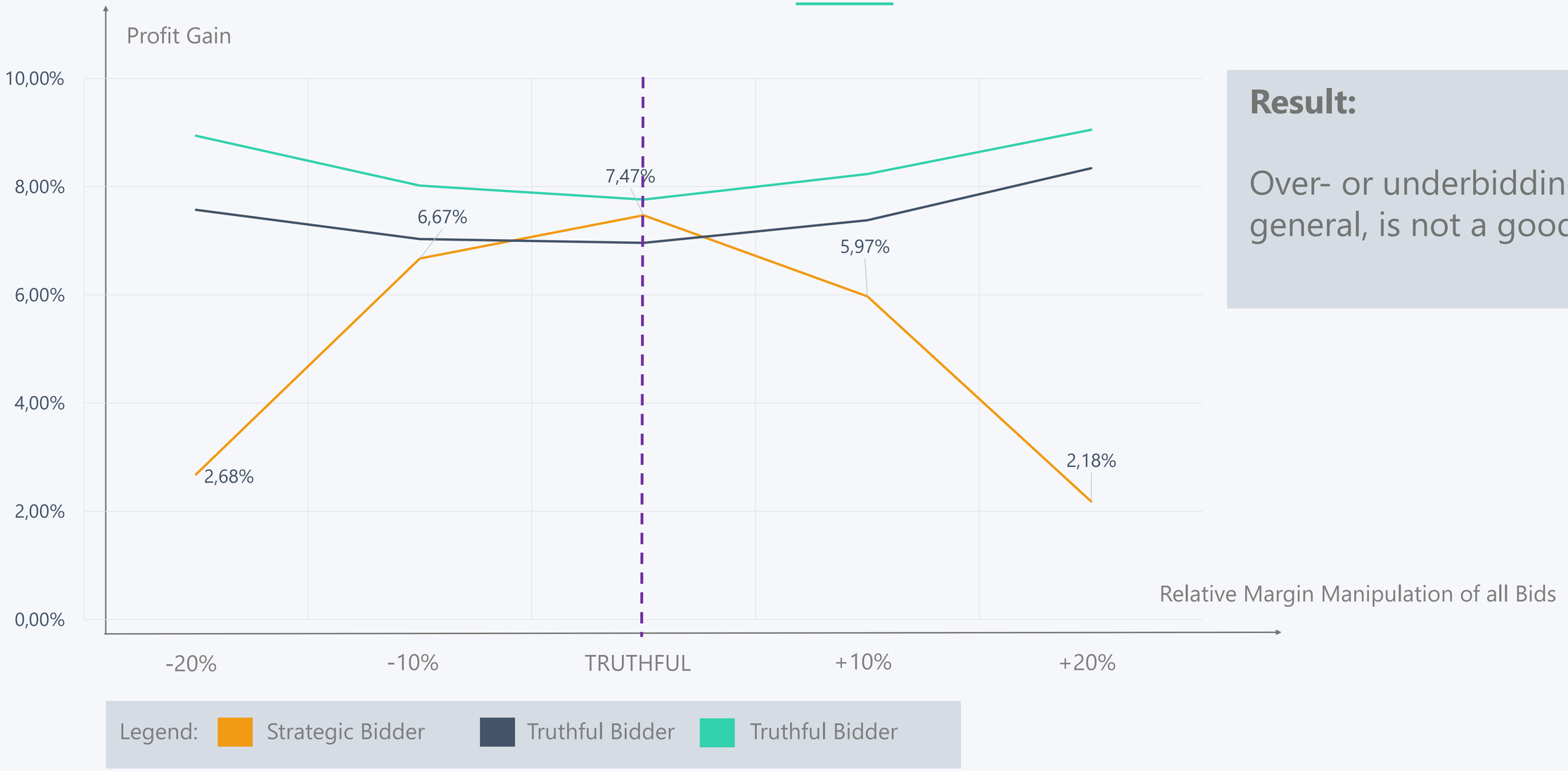


Result:

Overbidding on the Input Bid can increase profit

min ~16% increase of profit possible

Test Results for Strategic Bidder



Result:

Over- or underbidding, in general, is not a good idea

4.5 Bidding Strategies for Critical Weight Profit Sharing

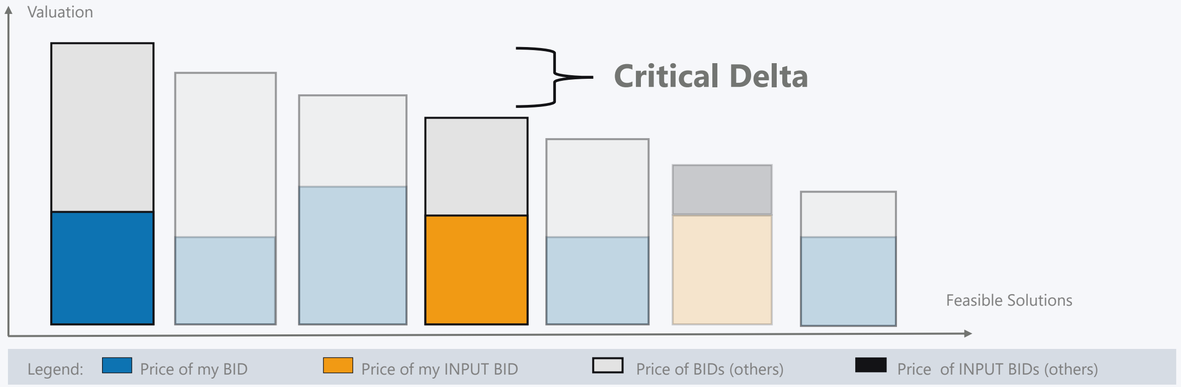
Critical Weight Profit Sharing

Profit Sharing Rule:

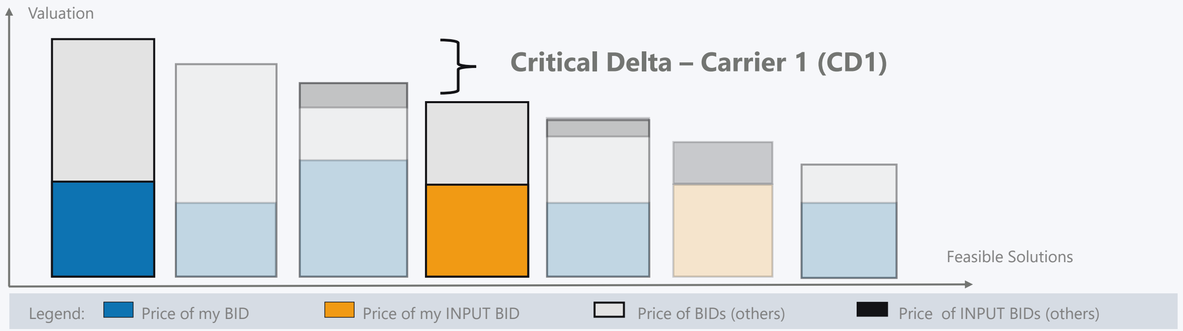
Use the **Critical Delta** for the calculation of the profit share

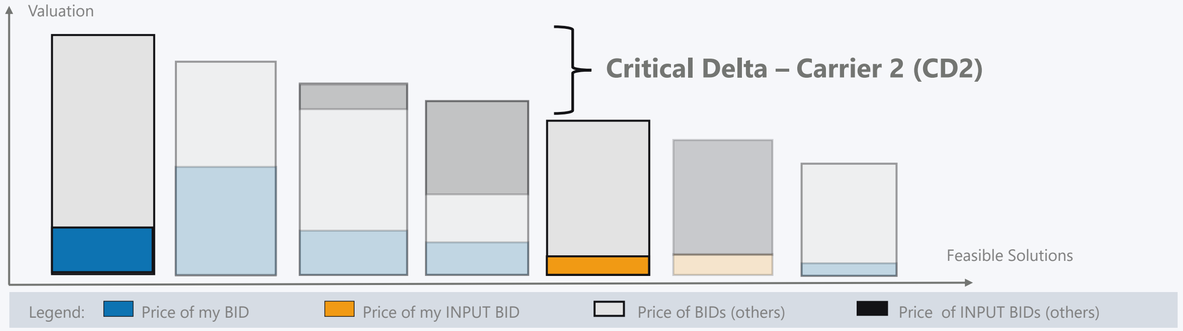
Note
Paying the **Critical Delta** to bidders would be equivalent to **paying** the **Vickrey-Clarke-Groves Payment** which creates an incentive compatible mechanisms (not budged balanced)

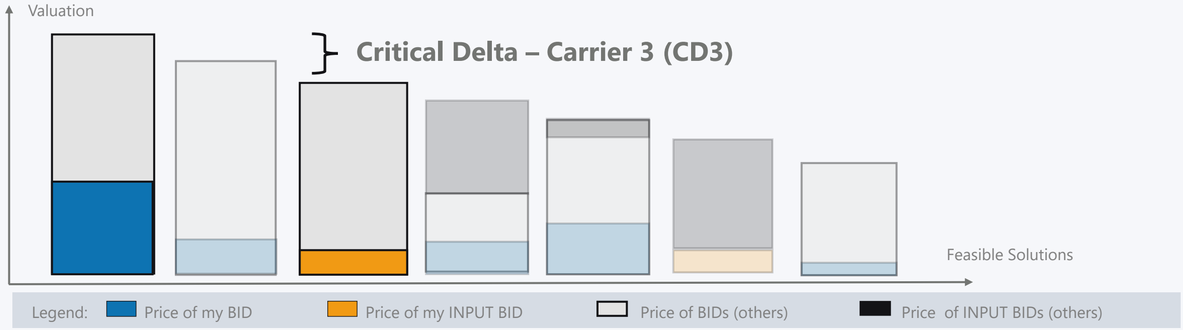
See [9]



Perspective of Conspiring Bidder







Critical Weight

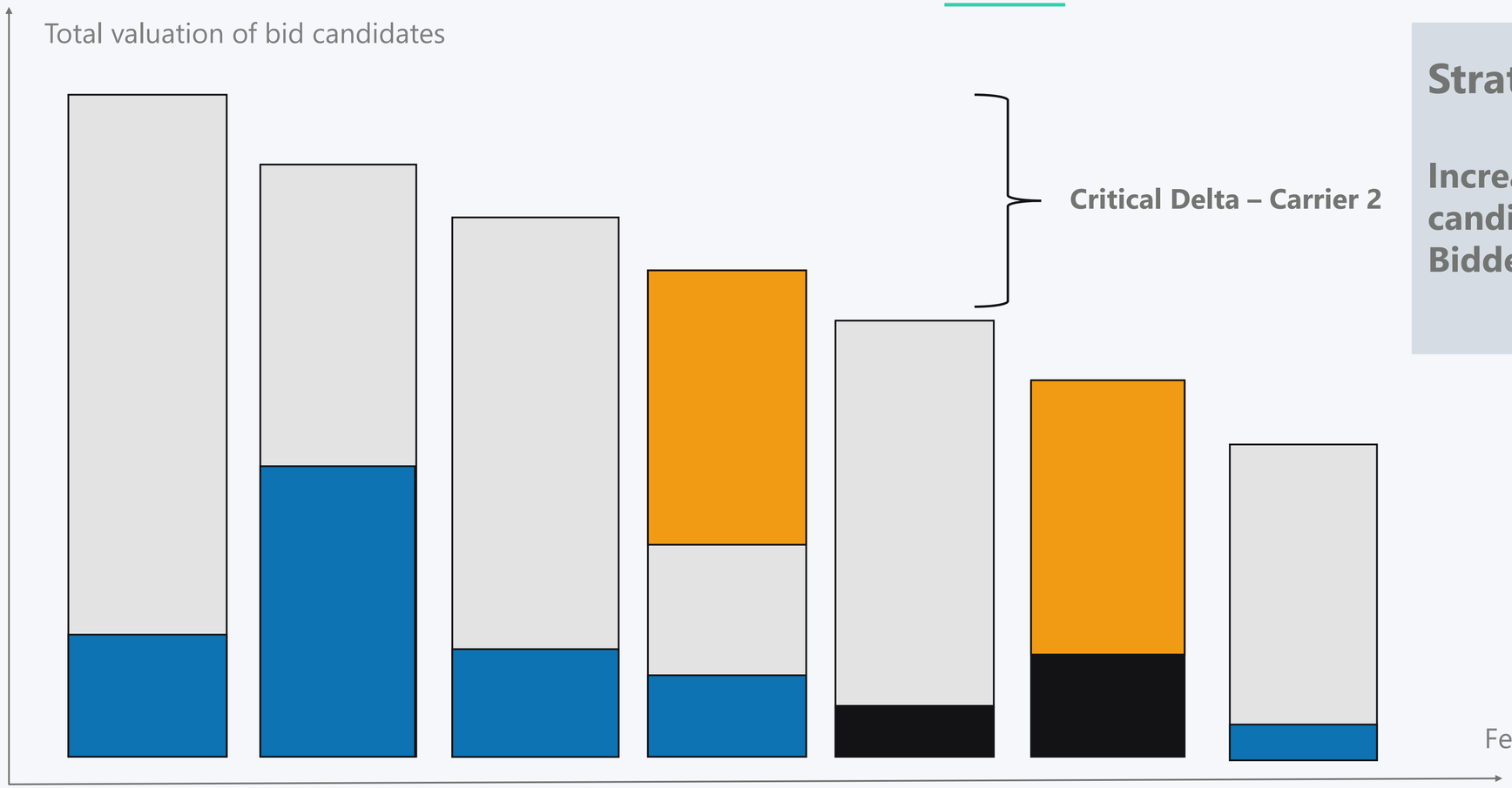
For Carrier 1:
CD1 / (CD1 + CD2 + CD3) **~ 33%**

For Carrier 2:
CD2 / (CD1 + CD2 + CD3) **~ 43%**

For Carrier 3:
CD3 / (CD1 + CD2 + CD3) **~ 24%**

Interpretation
Marginal contribution of the carrier
(however, less accurate than the Shapley Value because not considering all sub-coalitions)

Perspective of Conspiring Bidder

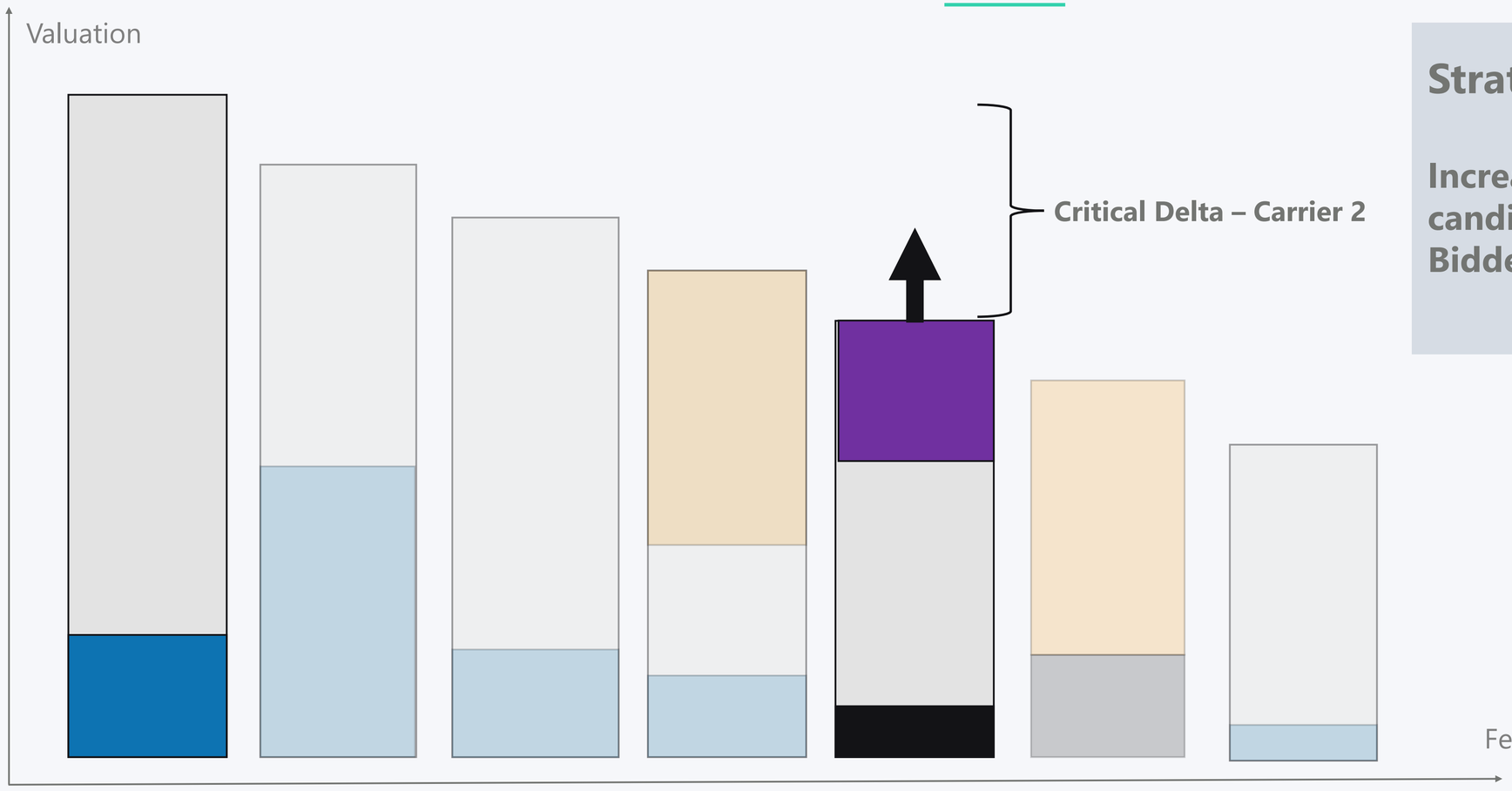


Strategy – DESTROY_WEIGHT

Increase valuation of a Bid of a candidate with an Input Bid of another Bidder as much as possible

Legend: Valuation of my BID | Valuation of my INPUT BID | Valuation of BIDs (others) | Valuation of INPUT BIDs (others)

Perspective of Conspiring Bidder

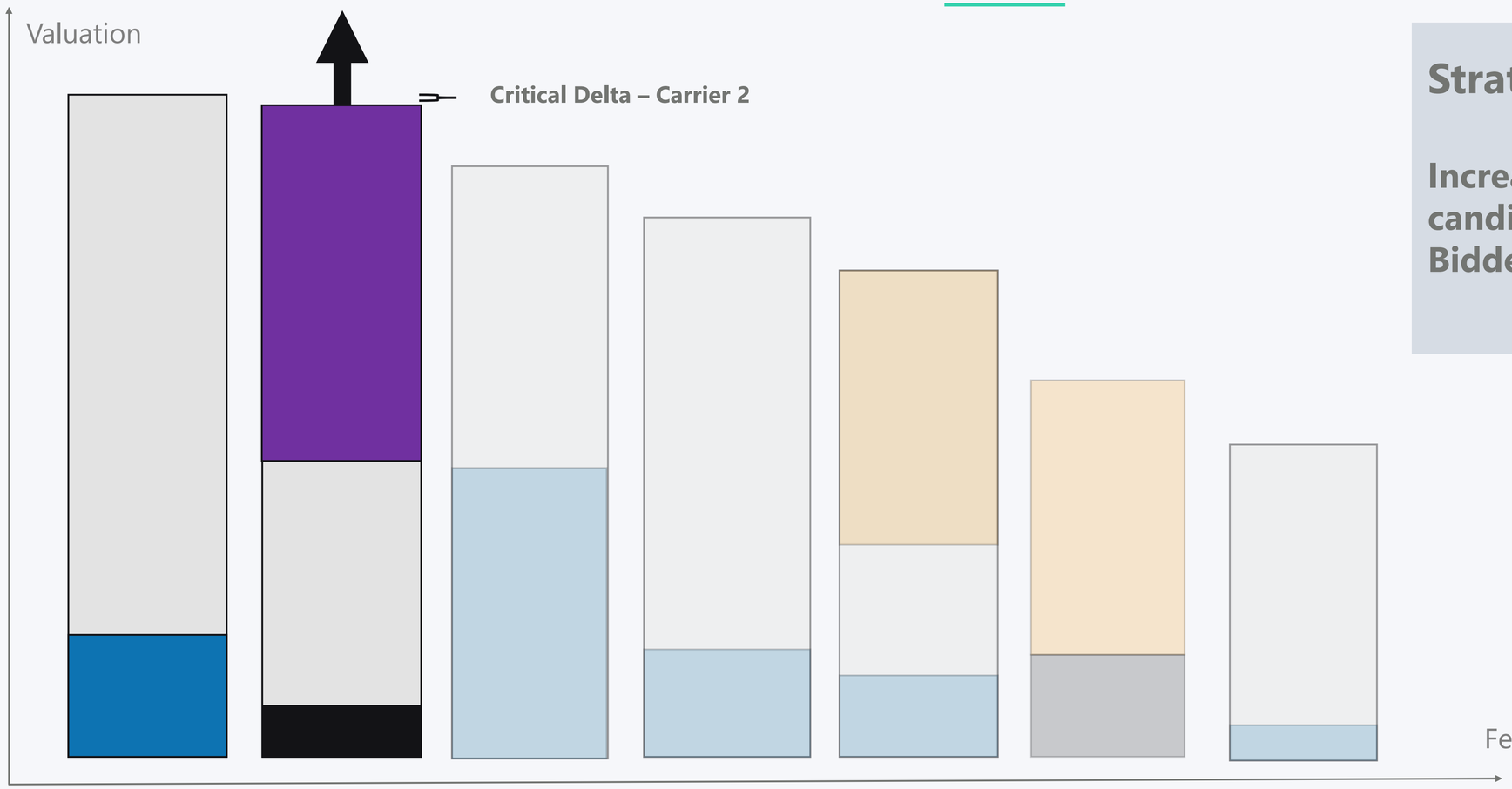


Strategy – DESTROY_WEIGHT

Increase valuation of a Bid of a candidate with an Input Bid of another Bidder as much as possible

Legend: Valuation of my BID | Valuation of my INPUT BID | Valuation of BIDs (others) | Valuation of INPUT BIDs (others) | Valuation of INPUT BID of Carrier 2

Perspective of Conspiring Bidder

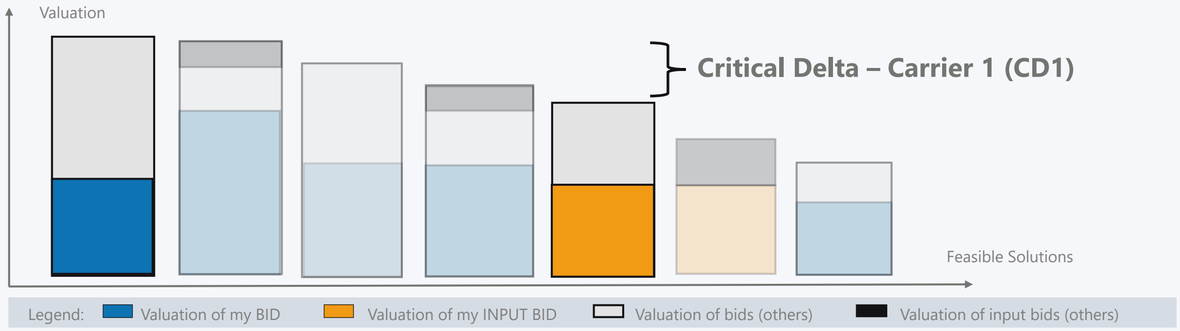


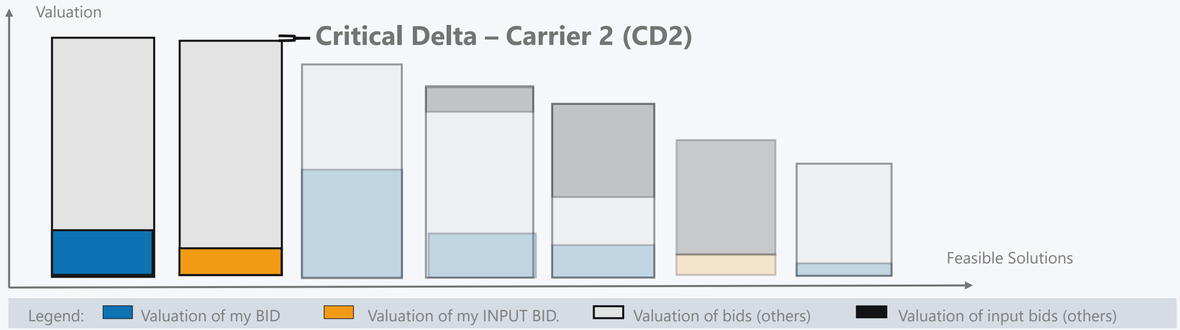
Strategy – DESTROY_WEIGHT

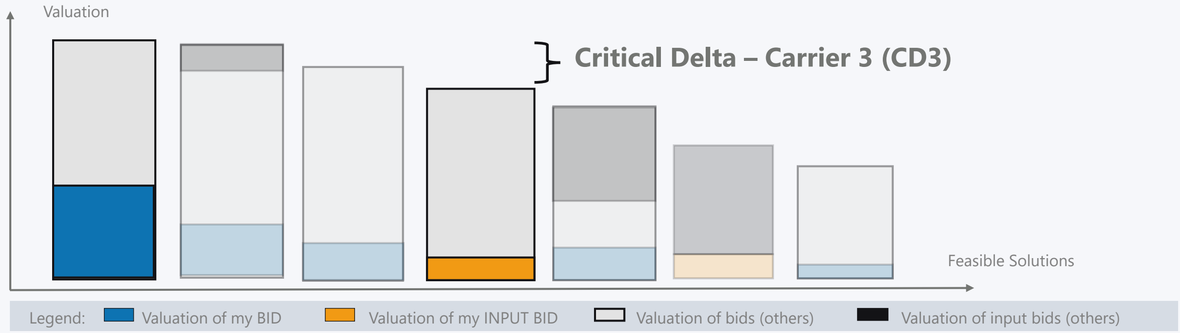
Increase valuation of a Bid of a candidate with an Input Bid of another Bidder as much as possible

Legend: Valuation of my BID | Valuation of my INPUT BID | Valuation of BIDs (others) | Valuation of INPUT BIDs (others) | Valuation of INPUT BID of Carrier 2

Perspective of Conspiring Bidder







Strategy – DESTROY_WEIGHT

Increase valuation of a Bid of a candidate with an Input Bid of another Bidder as much as possible

For Bidder 1:
CD1 / (CD1 + CD2 + CD3) **~ 57%**
→ **(+)** Increase of Collaboration Share

For Bidder 2:
CD2 / (CD1 + CD2 + CD3) **~ 0%**
→ **(-)** Decrease of Collaboration Share

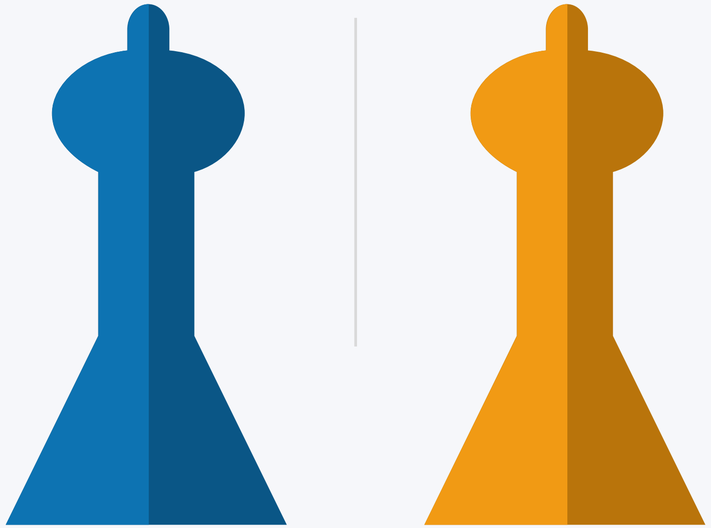
For Bidder 3:
CD3 / (CD1 + CD2 + CD3) **~ 43%**
→ **(+)** Increase of Collaboration Share

Strategies

Conspiring Bidder Strategies

INPUT_MAX
Increase price of Input Bid

DESTROY_WEIGHT
Increase prices of bids in the feasible solutions with an Input Bid of other carrier(s) as much as possible



Strategic Bidder Strategies

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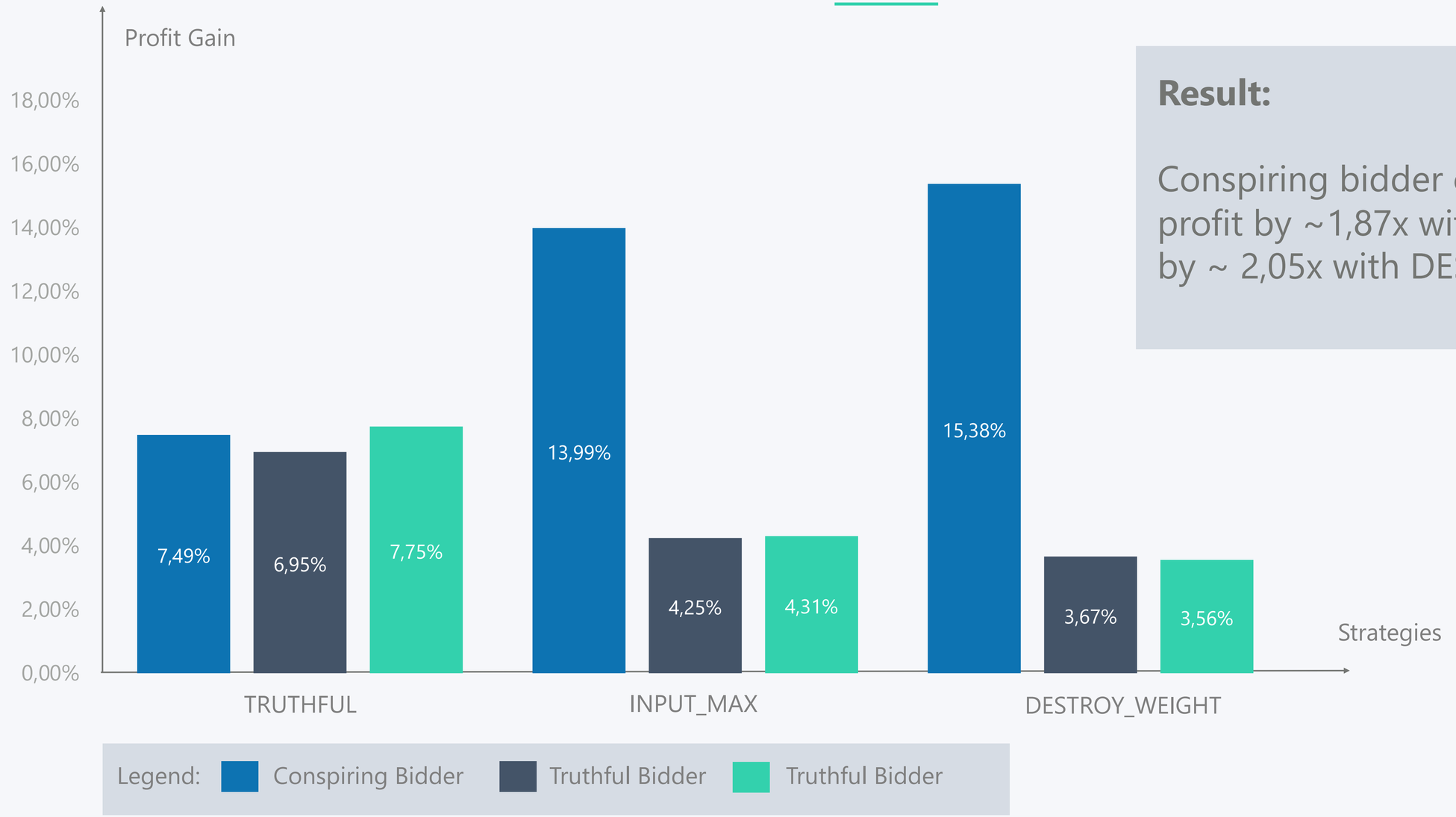
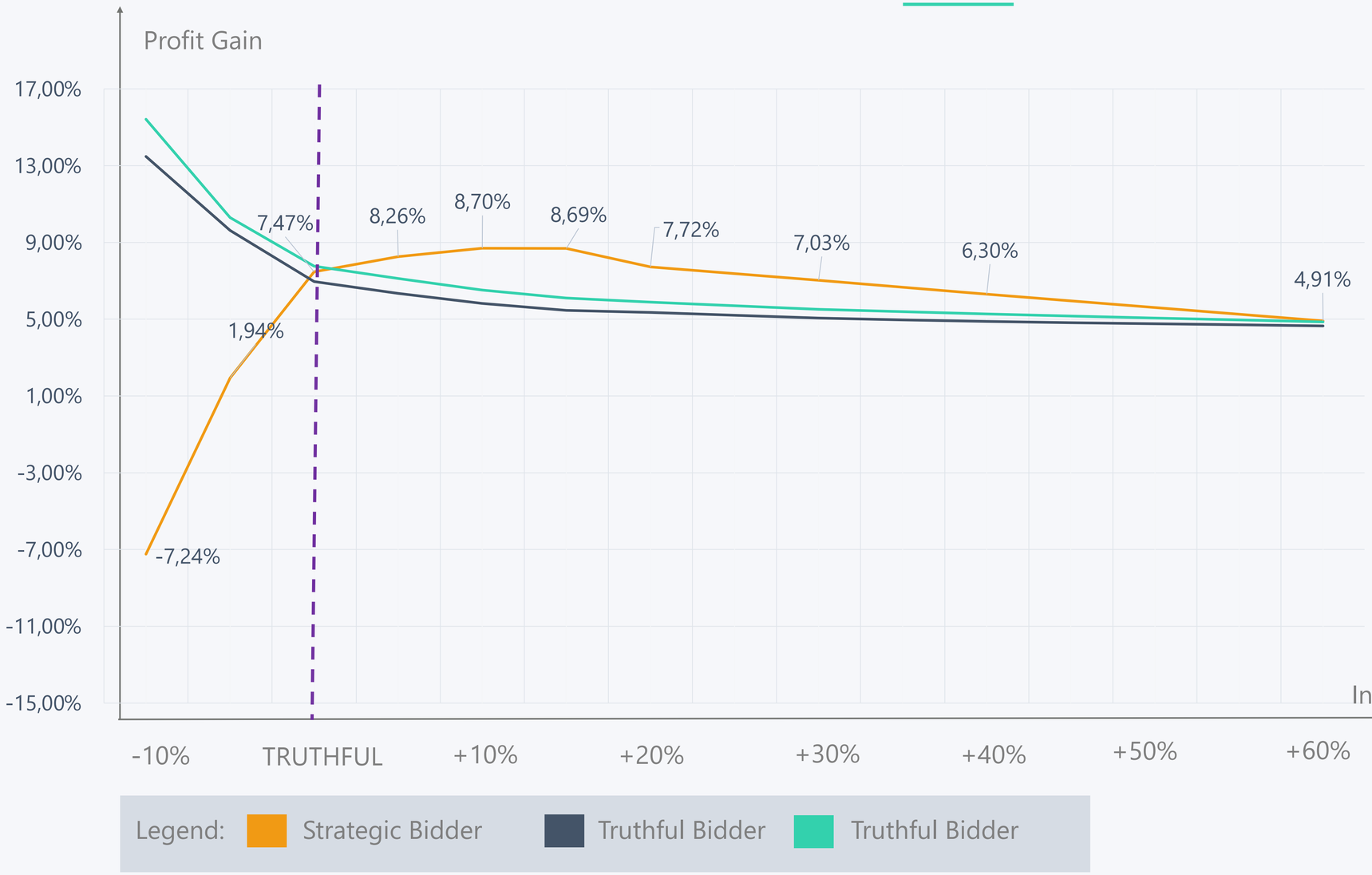
Test Results for Conspiring Bidder



Result:

Conspiring bidder can increase her profit by ~1,87x with INPUT_MAX and by ~ 2,05x with DESTROY_WEIGHT

Test Results for Strategic Bidder



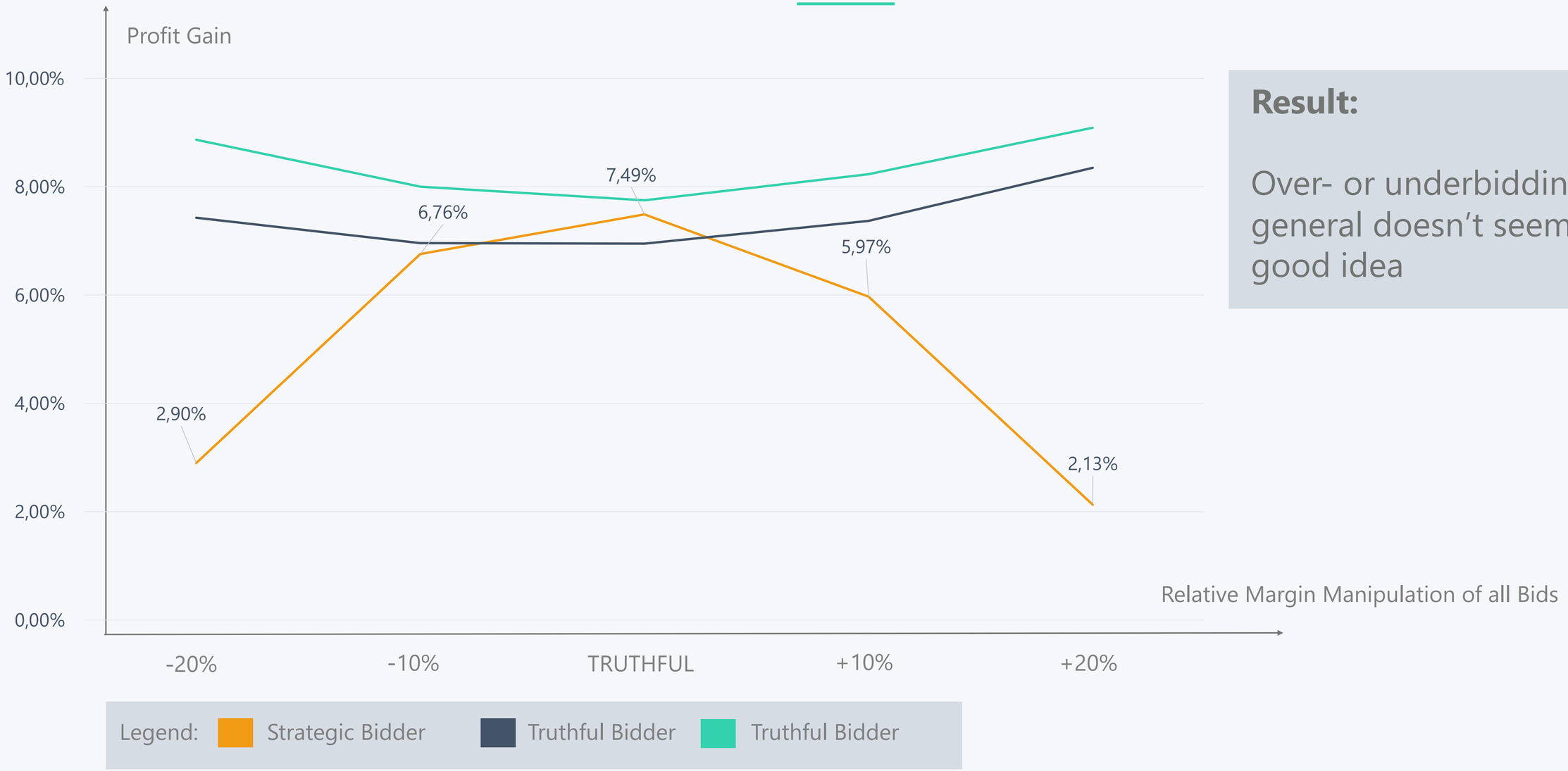
Result:

Overbidding on the Input Bid can increase profit

min ~16% increase of profit possible

[squared weight
min ~13% profit increase
cubic weight
min~11% profit increase]

Simulation Results for Strategic Bidder



Result:

Over- or underbidding in general doesn't seem to be a good idea

5 Comparison of the analysed Profit Sharing Methods

Comparison

Egalitarian

- ✓ computational efficient
- ✓ easy to understand
- ✗ could be considered unfair
- ✗ encourages overbidding the Input Bid

(Sidenote: Modified Egalitarian superior)

Purchase/Sale Weights

- ✓ computational efficient
- ✓ incentivizes contribution
- ✗ manipulable through overbidding

Shapley Value

- ✓ well-known economic formula
- ✓ desirable economic properties*
- ✓ could be considered fair
- ✓ quite robust against strategic manipulation
- ✗ computational inefficient
- ✗ requires evaluation of all sub-coalitions

* e.g., efficieny, symmetry, linearity, null player exclusion, anonymity etc. *See [9]*

Critical Weights

- ✓ could be considered fair
- ✓ robust against simple strategic manipulation
- ✓ no need to evaluate all sub-coalitions
- ✗ less easy to understand
- ✗ potentially vulnerable to complex strategies

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Critical Weights

- ✓ could be considered fair
- ✓ robust against simple strategic manipulation
- ✓ no need to evaluate all sub-coalitions
- ✗ less easy to understand
- ✗ potentially vulnerable to complex strategies

6 Outlook

Overview of Research Topics

Potentially part of my Master Thesis

- Comparison of the Shapley Value and Critical Weight Profit Sharing for more than 3 carriers
- Research/Development of complex strategies for manipulating the Shapley Value or Critical Weight Profit Sharing

Further Research

- Evaluation of strategic behaviour during the request selection phase
- Evaluation/development of additional profit sharing methods
- Evaluation of various methods that approximate the Shapley Value
- Evaluation of equilibria and expected outcomes of a setting with multiple strategic carriers
- Strategic evaluation of payment methods that don't guarantee Individual Rationality
- Experimental analysis of strategic behaviour

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