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Strategic Manipulation of Bids in Auction-Based Transport Collaborations

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University:	University of Vienna

Agenda

1 Introduction to Transport Collaborations

2 Implementation of Auction-based Transport Collaborations

3 Payment Calculation and Profit Sharing Methods in Auction-based Transport Collaborations

4 Strategic Manipulation of Bids in Auction-based Transport Collaborations

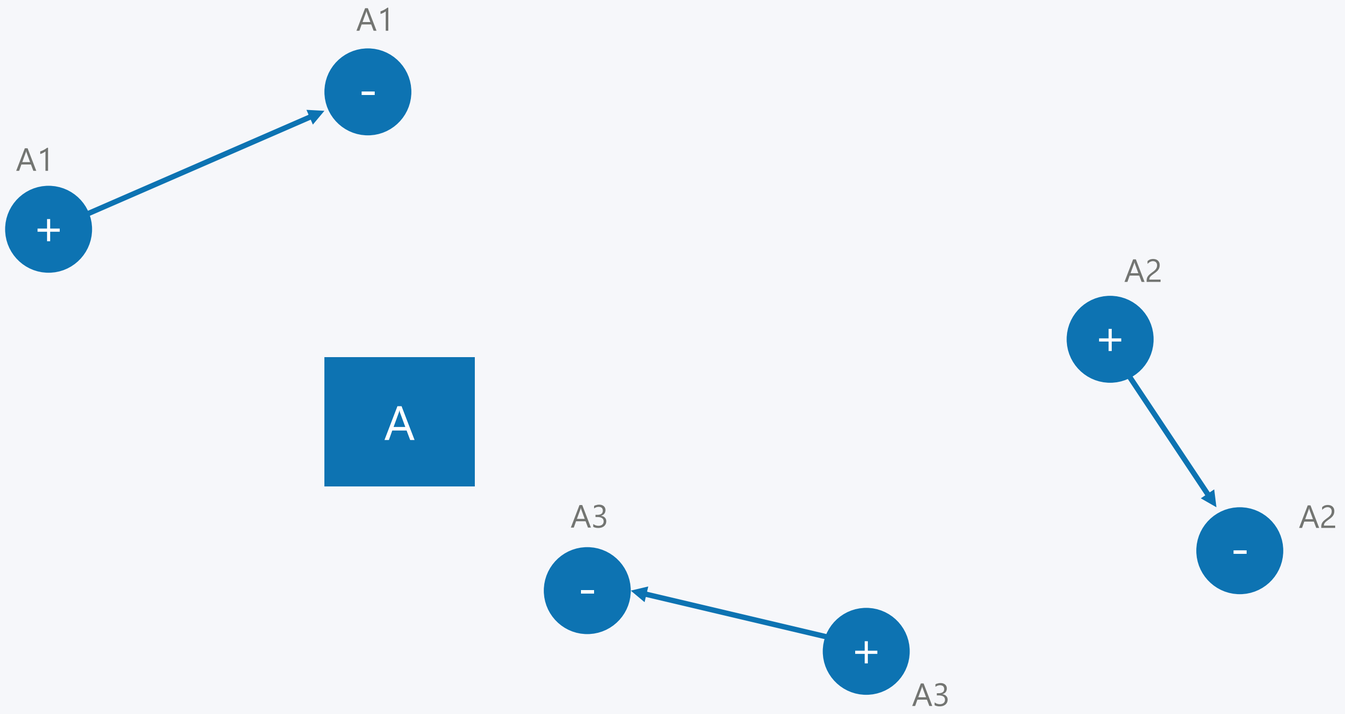
- *4.1 Bidding Strategies for Egalitarian Profit Sharing*
- *4.2 Bidding Strategies for Modified Egalitarian Profit Sharing*
- *4.3 Bidding Strategies for Purchase/Sale Weight Profit Sharing*
- *4.4 Bidding Strategies for Shapley Value Profit Sharing*
- *4.5 Bidding Strategies for Critical Weight Profit Sharing*

5 Comparison of the analysed Profit Sharing Methods

6 Outlook

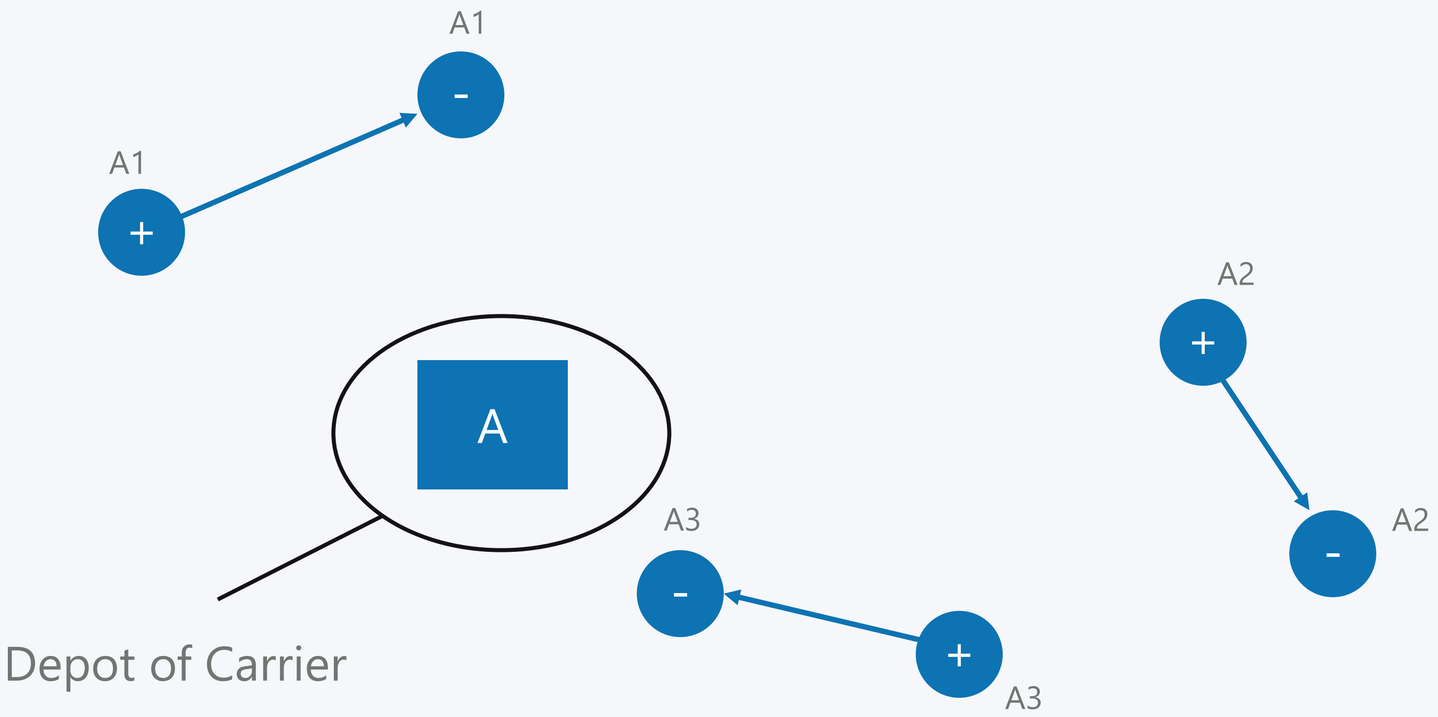
1 Introduction to Transport Collaborations

Initial Situation



Legend: Depot Pickup Delivery

Initial Situation– Depot



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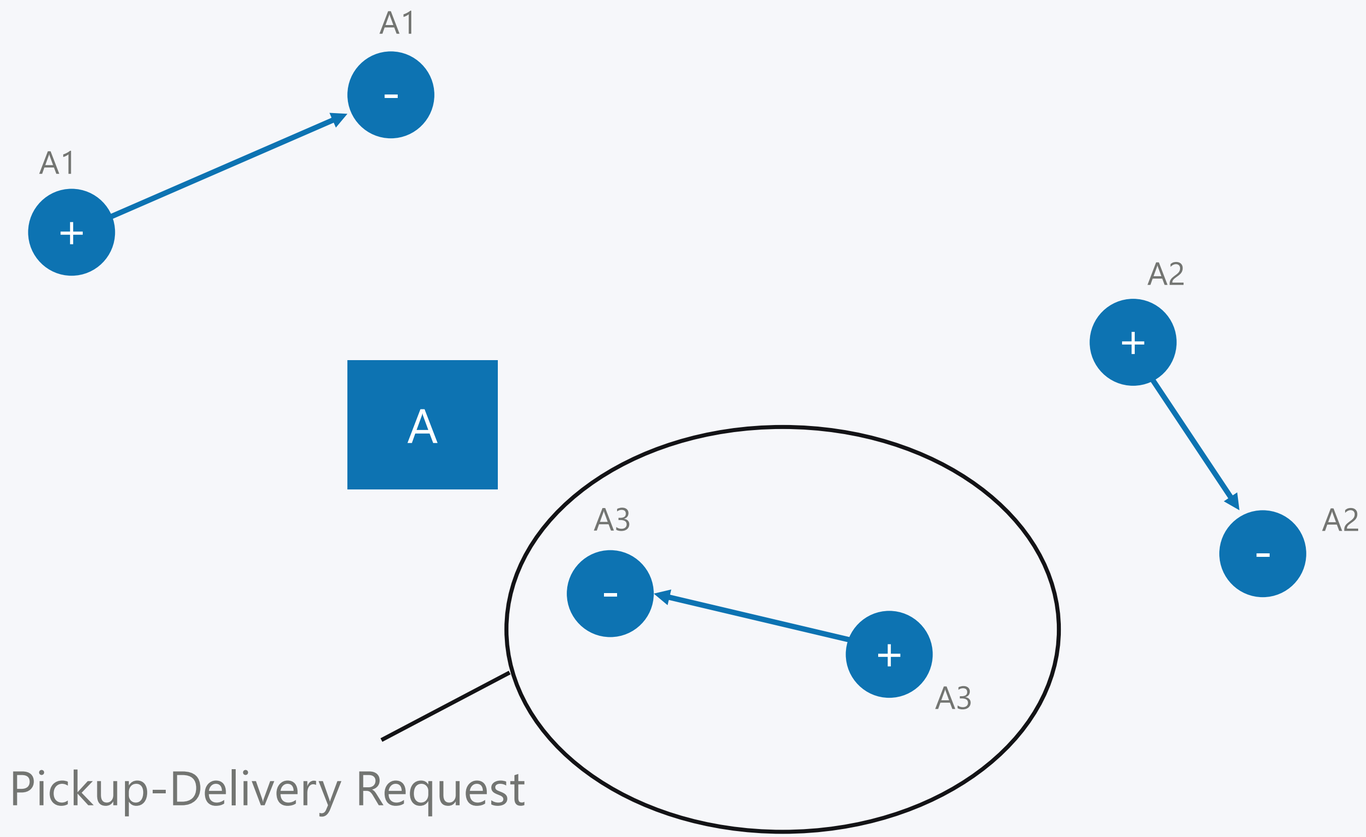
Initial Situation– Pickup-Delivery Requests



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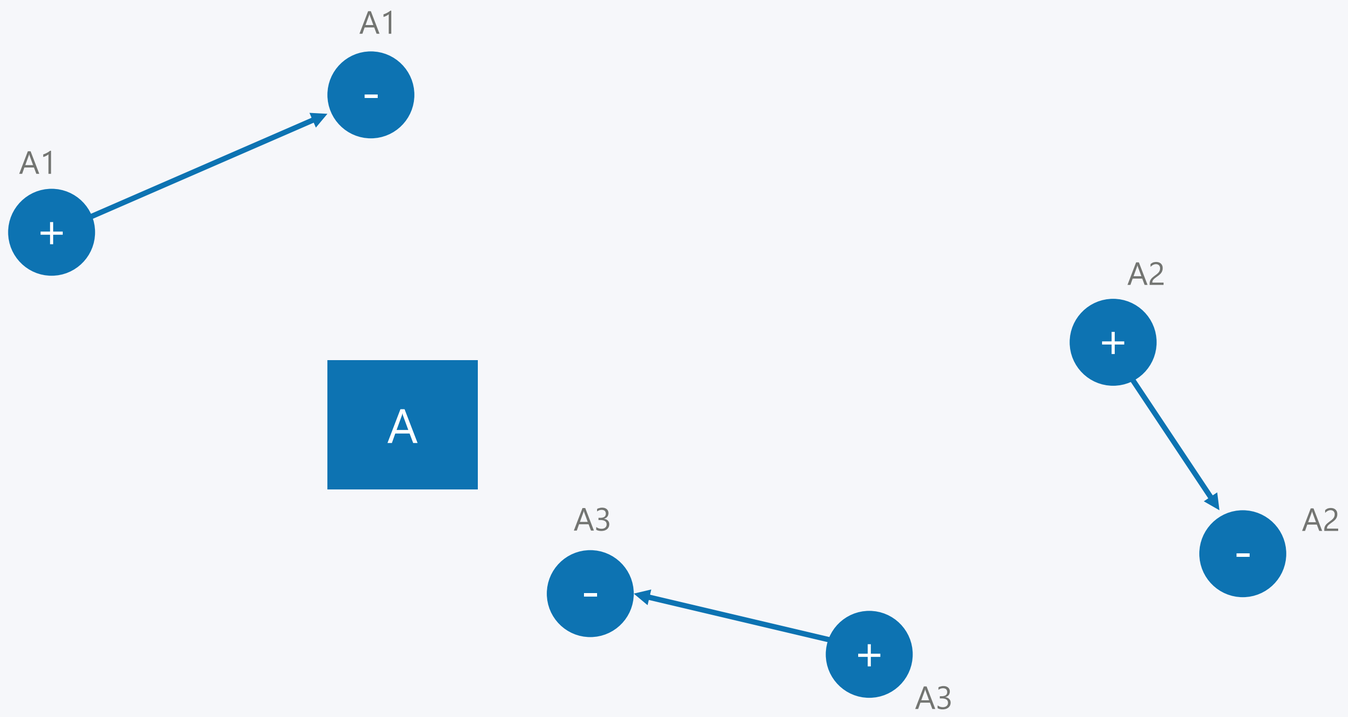
Initial Situation - Revenue Calculation



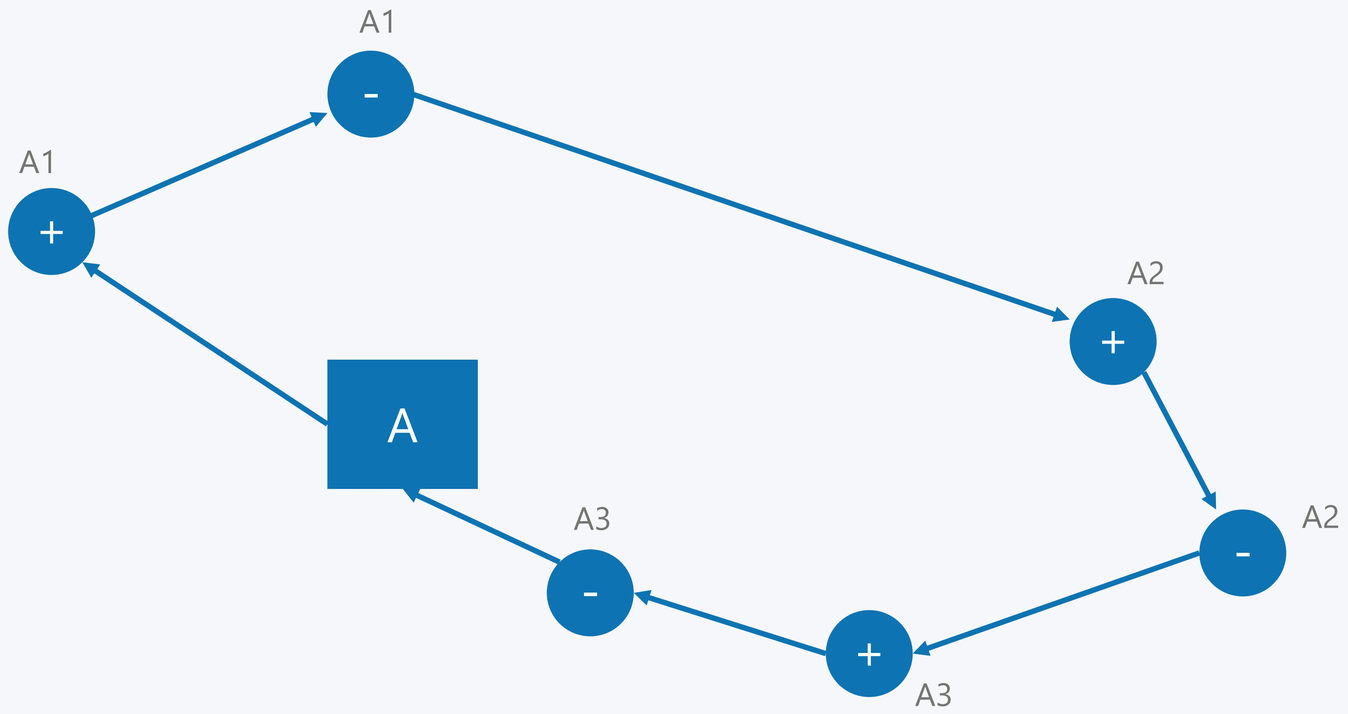
Revenue

Request Revenue
(+) Fixed Revenue
(+) Variable Revenue * Direct Length

Total Revenue
(+) Sum[Request Revenues]

Legend: Depot Pickup Delivery

Initial Situation - Cost Calculation



Costs

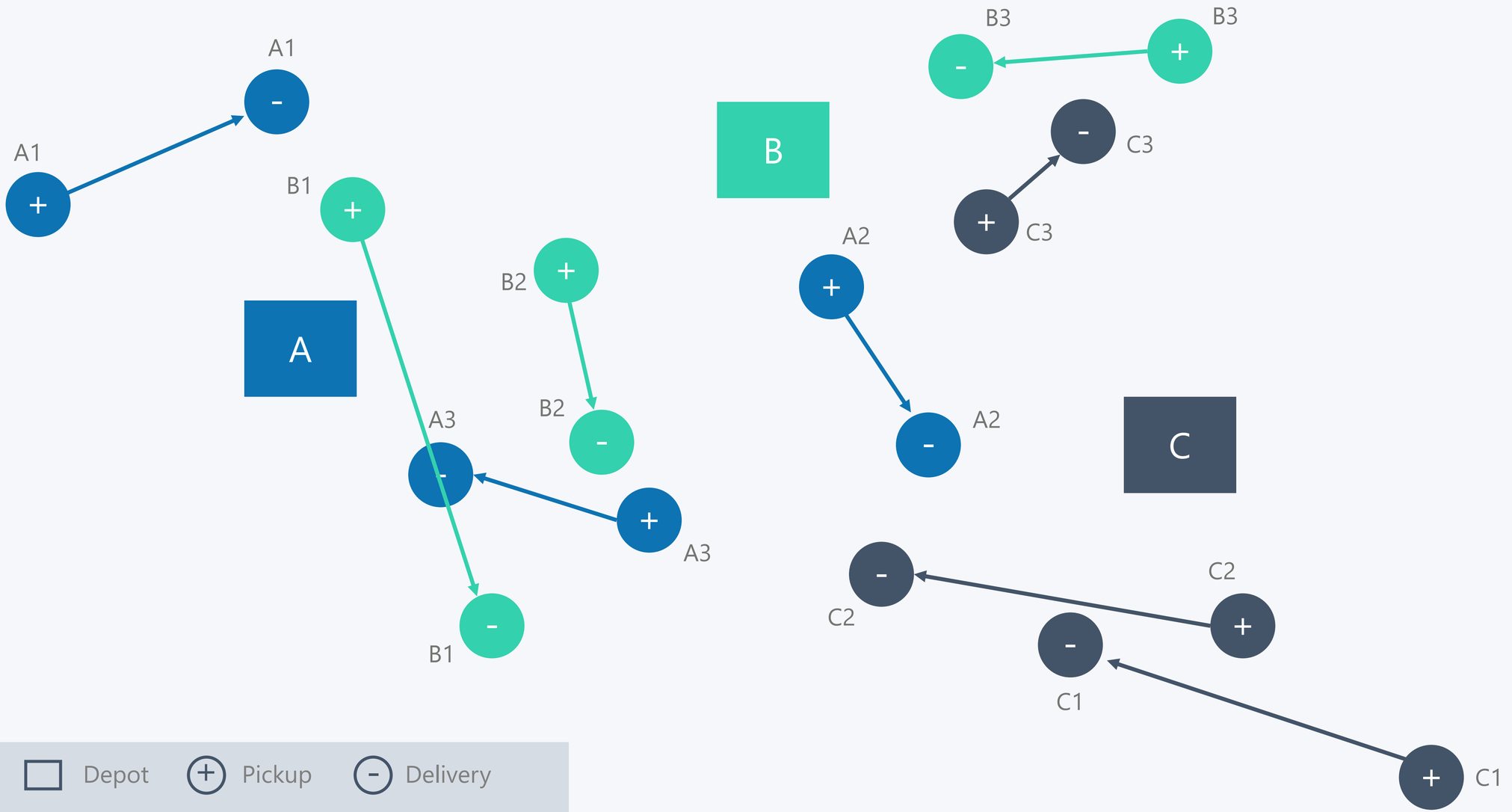
Total Costs
(-) Variable Cost * Routing Distance

Marginal Cost Request
(-) Variable Cost * Marginal Routing Distance

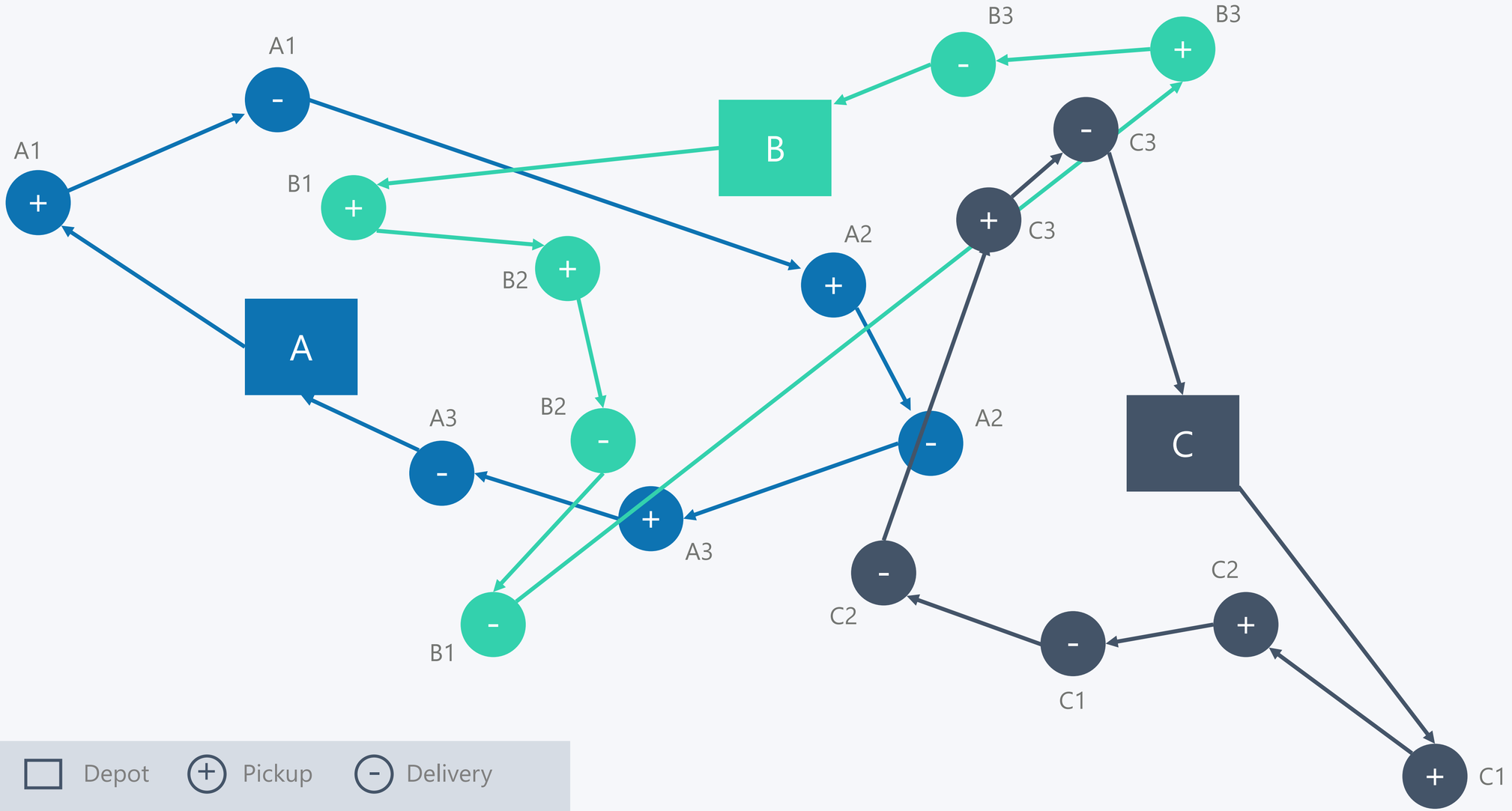
→ Maximize Profit by optimizing the route

Legend: Depot Pickup Delivery

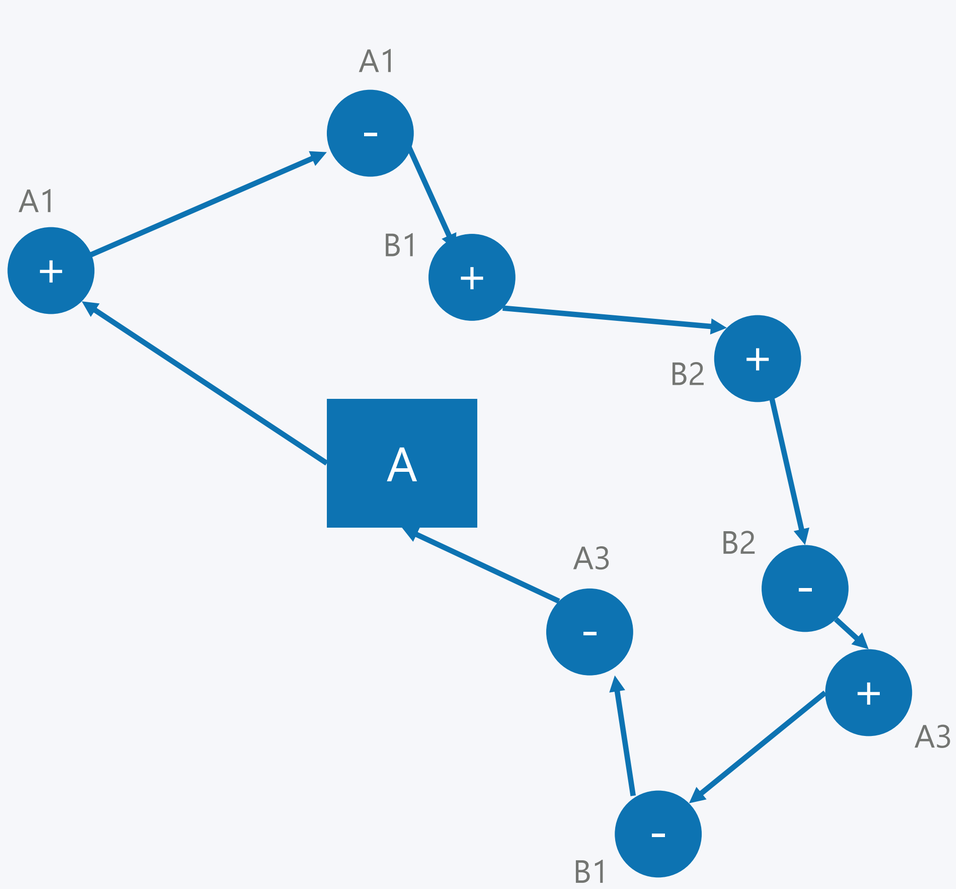
Introduction of Multiple Carriers

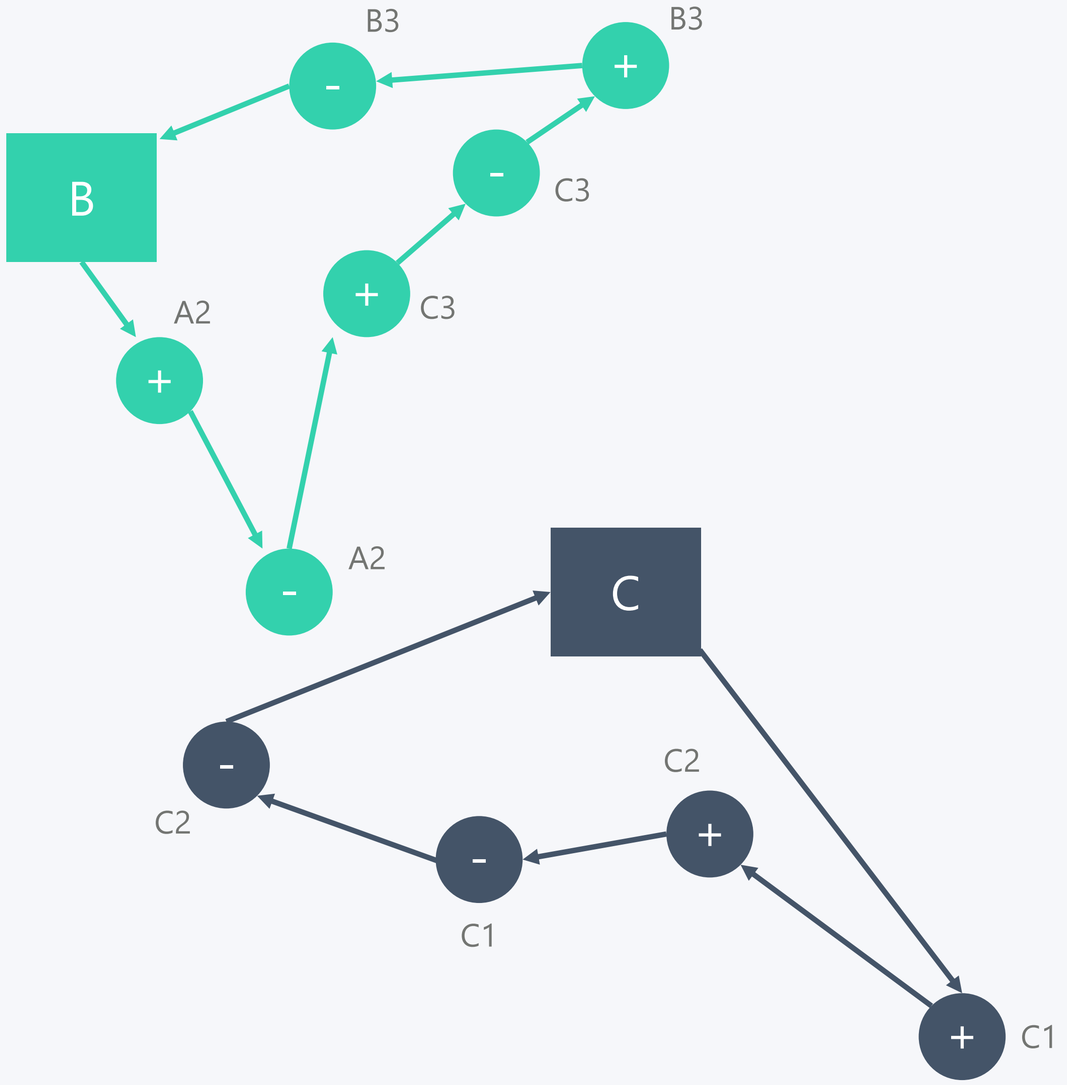


Starting Point – Decentralized Routing Solution



Centralized Routing Solution





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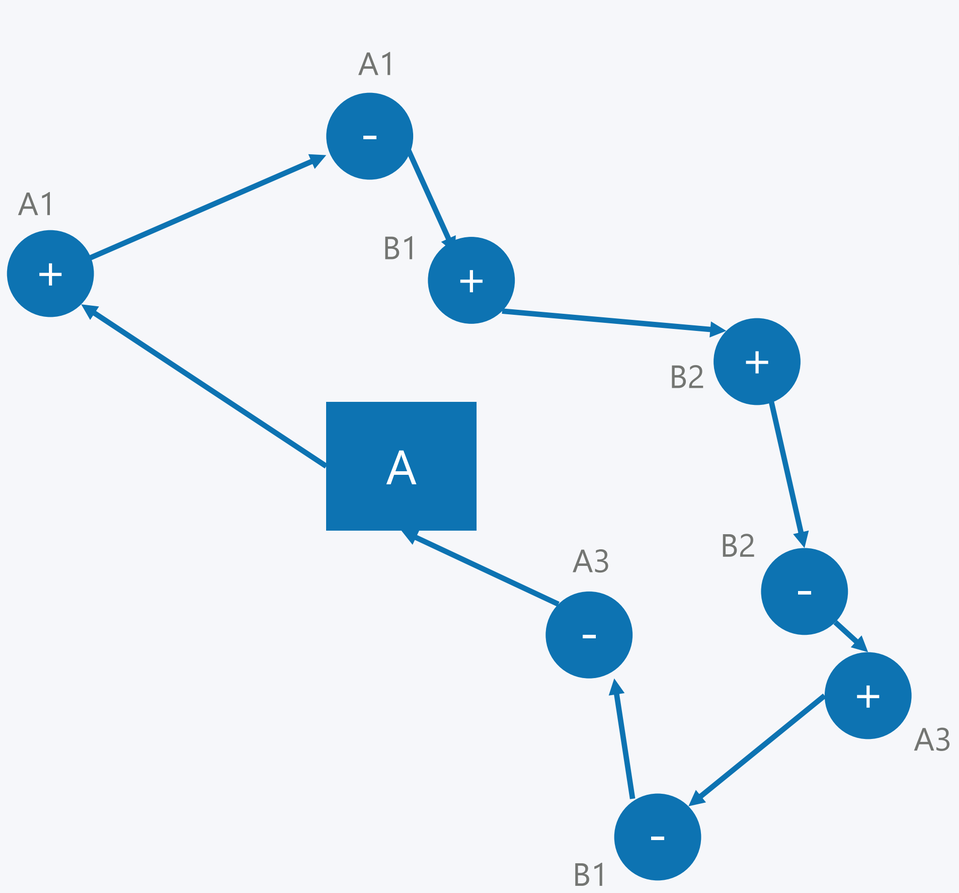
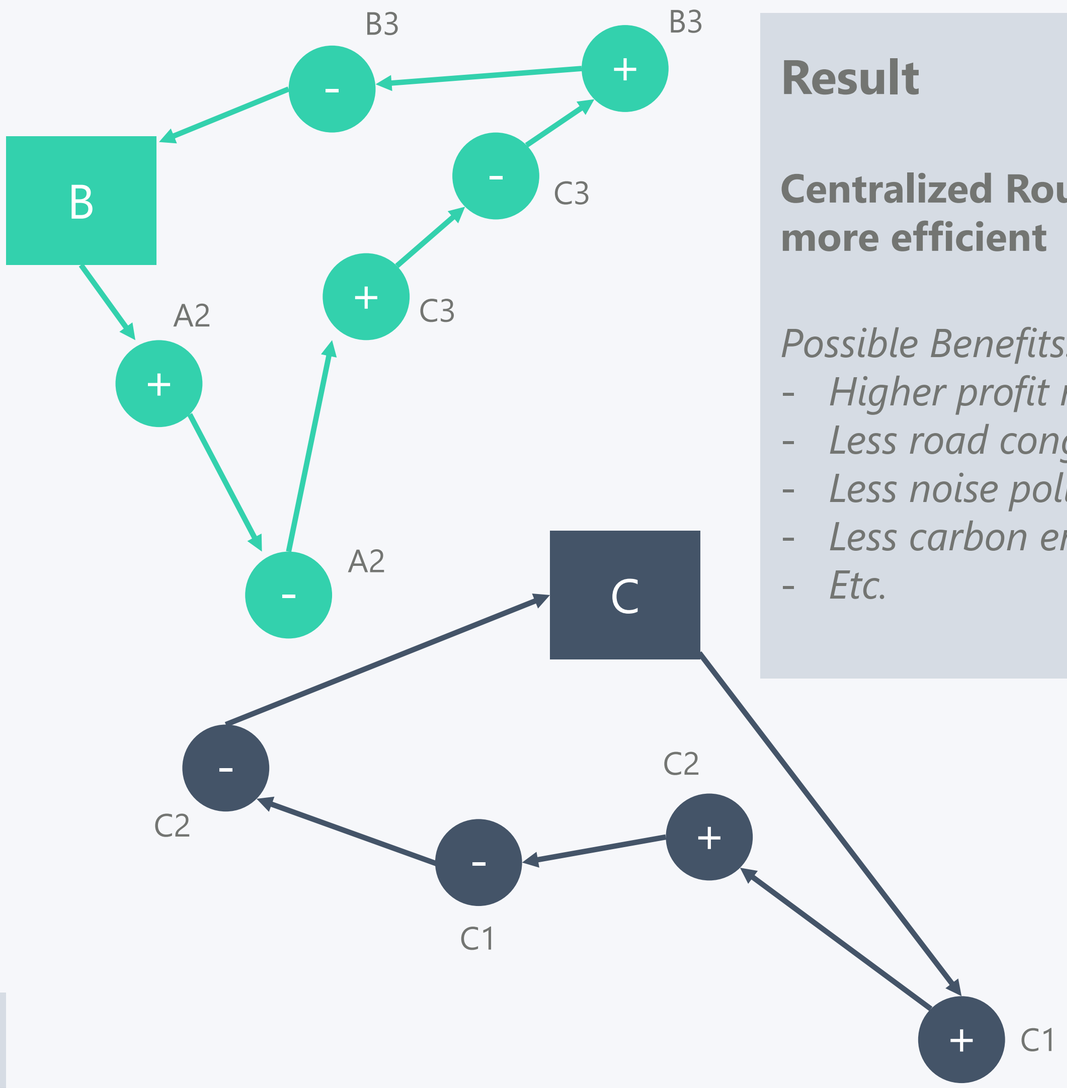




Legend: Depot Pickup Delivery

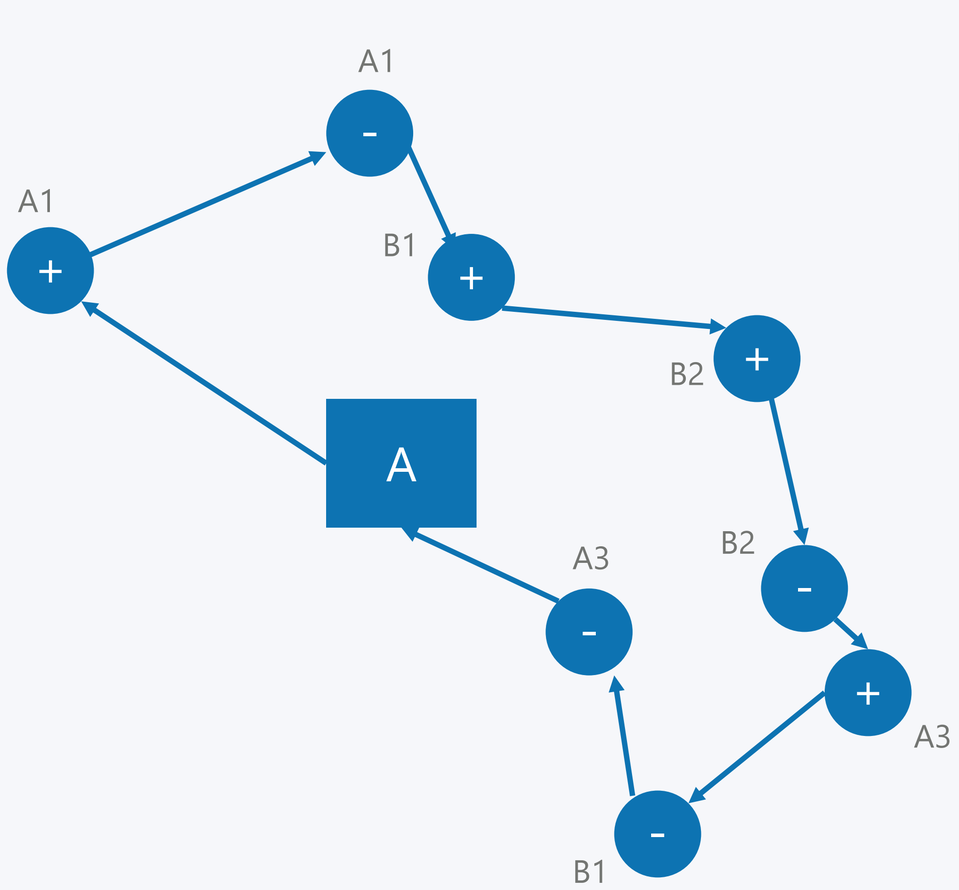
Result

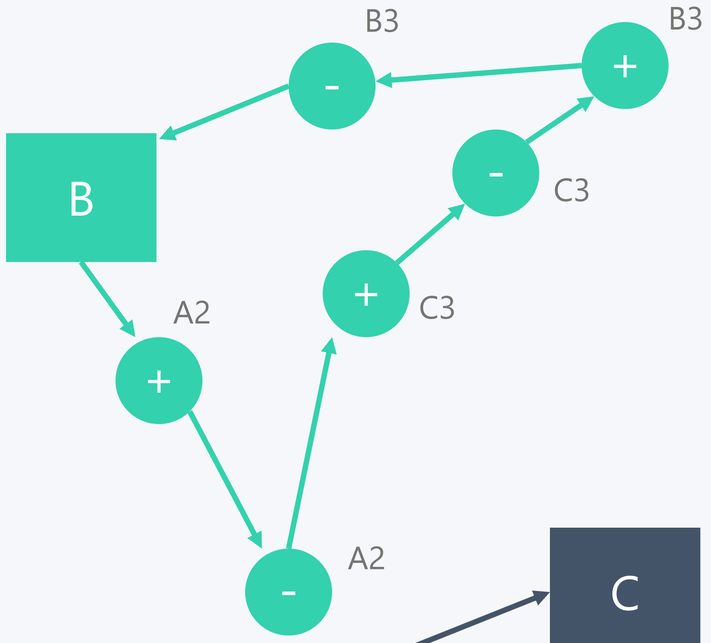
Centralized Routing Solution is more efficient

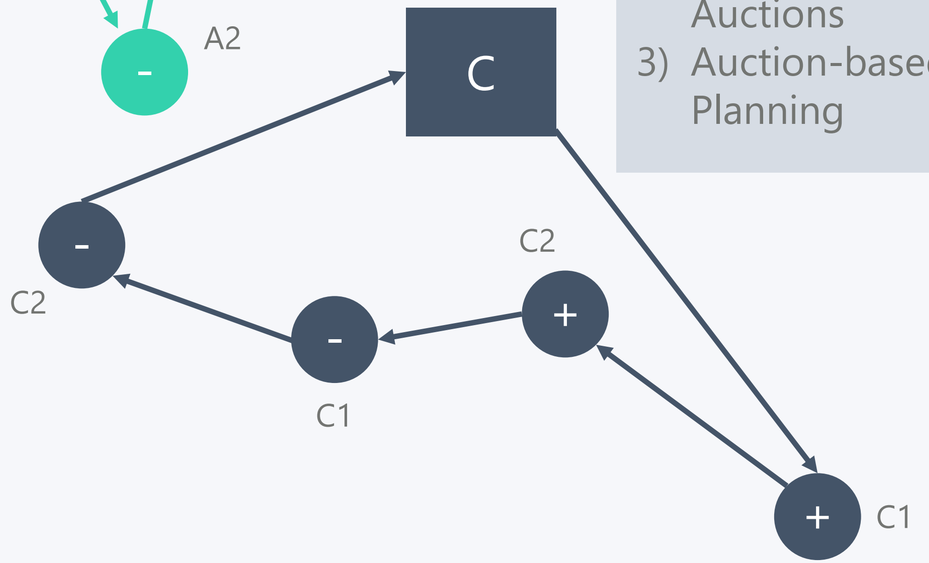
Possible Benefits:
- *Higher profit margins*
- *Less road congestion*
- *Less noise pollution*
- *Less carbon emissions*
- *Etc.*

See [4]

Centralized Routing Solution







Legend: Depot Pickup Delivery

Problem

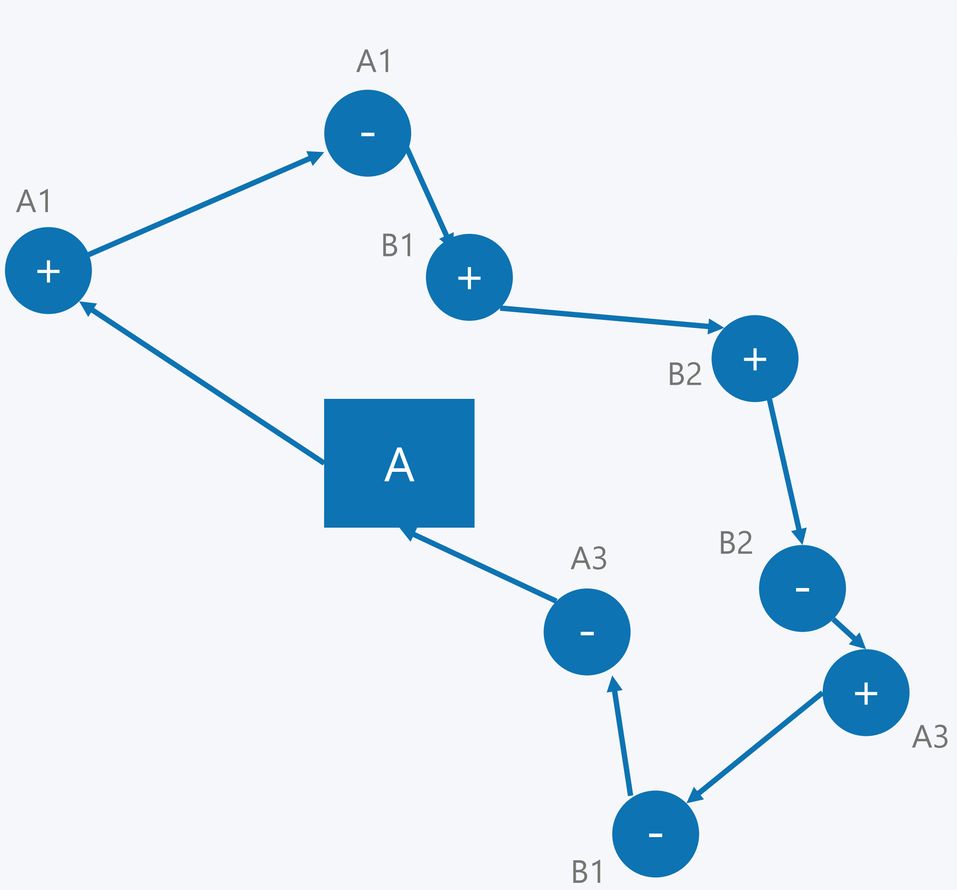
How to trade the Pickup-Delivery requests?

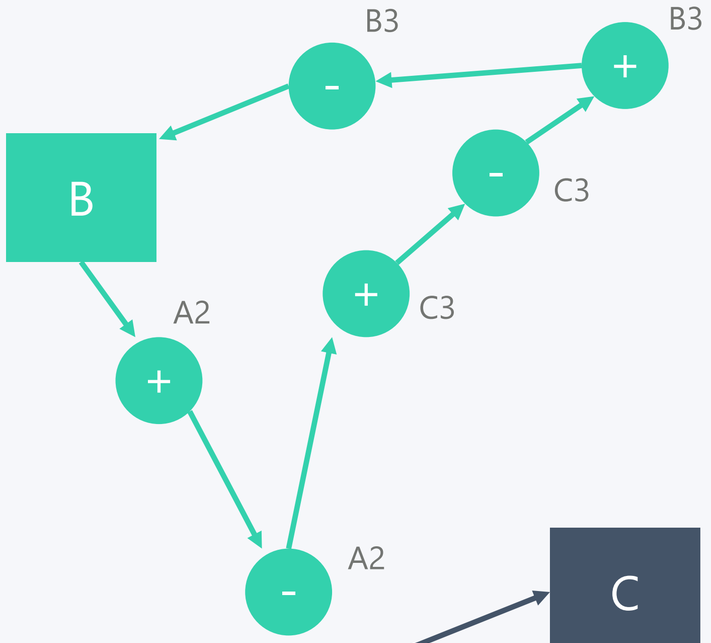
Options:

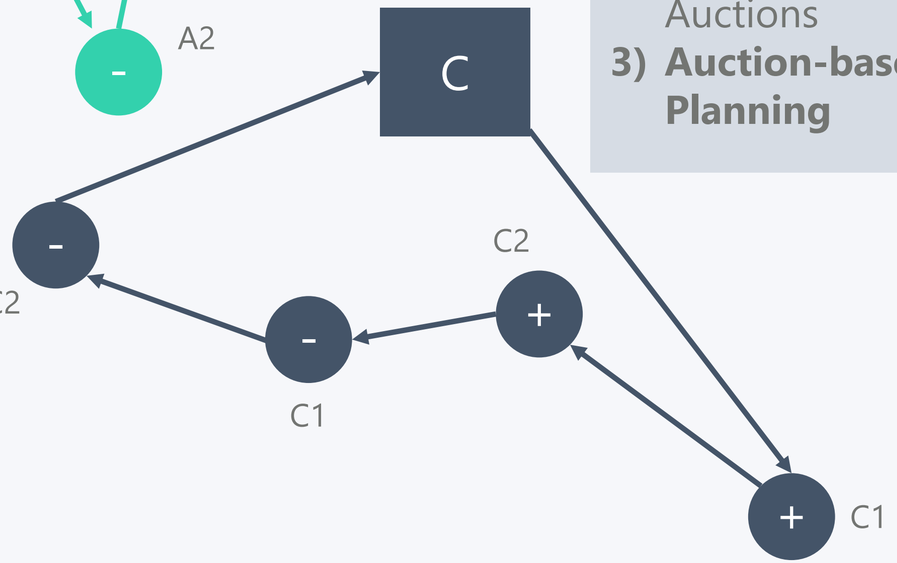
1) Centralized Collaborative Planning
2) Decentralized Planning without Auctions
3) Auction-based Decentralized Planning

See [4]

Centralized Routing Solution







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Problem

How to trade the Pickup-Delivery requests?

Options:

1) Centralized Collaborative Planning
2) Decentralized Planning without Auctions
3) **Auction-based Decentralized Planning**

See [4]

2 Implementation of Auction-based Transport Collaborations

Auction-based Mechanism

Auction-based mechanism

Coordinated by a mechanism manager

1) Each carrier should **select pickup-delivery requests** that she/he is willing to trade and state a price (**Input Bid**)

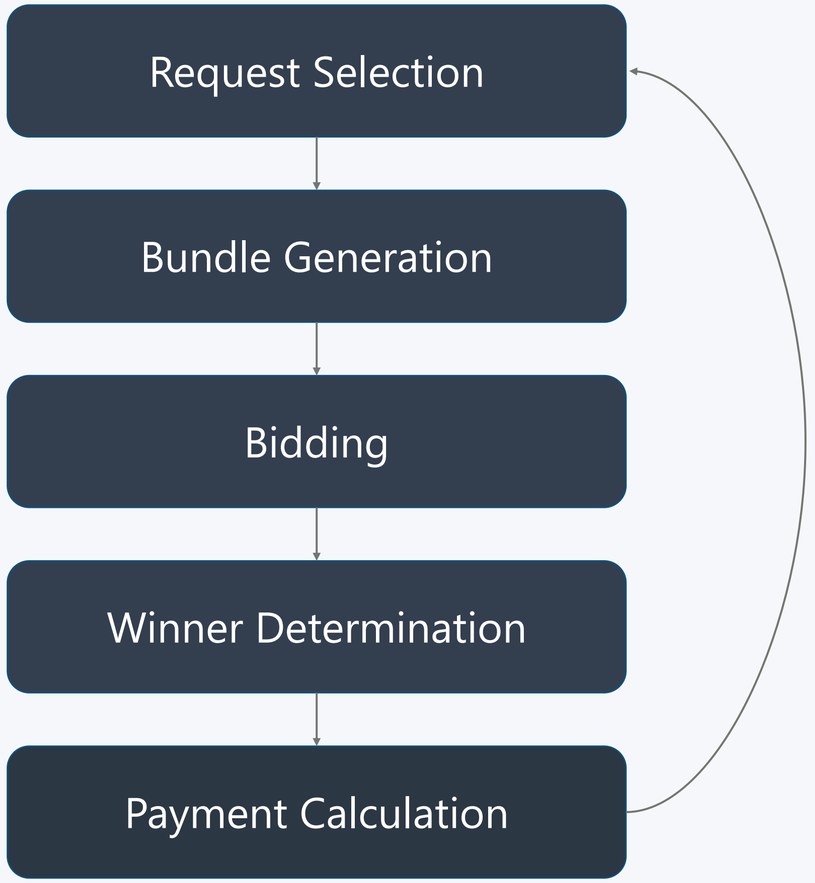
2) The mechanism manager has to **bundle the requests** to attractive packages

3) Each carrier has to **select a price** that she/he is willing to pay for the offered **bundles** (**Bid**)

4) The mechanism manager has to **determine** the **optimal bids** and allocate the requests **(Winning Bids)**

5) The mechanism manager has to **determine** the **payments** for each carrier

(6) Mechanism terminates or restarts at 1))



See [1]

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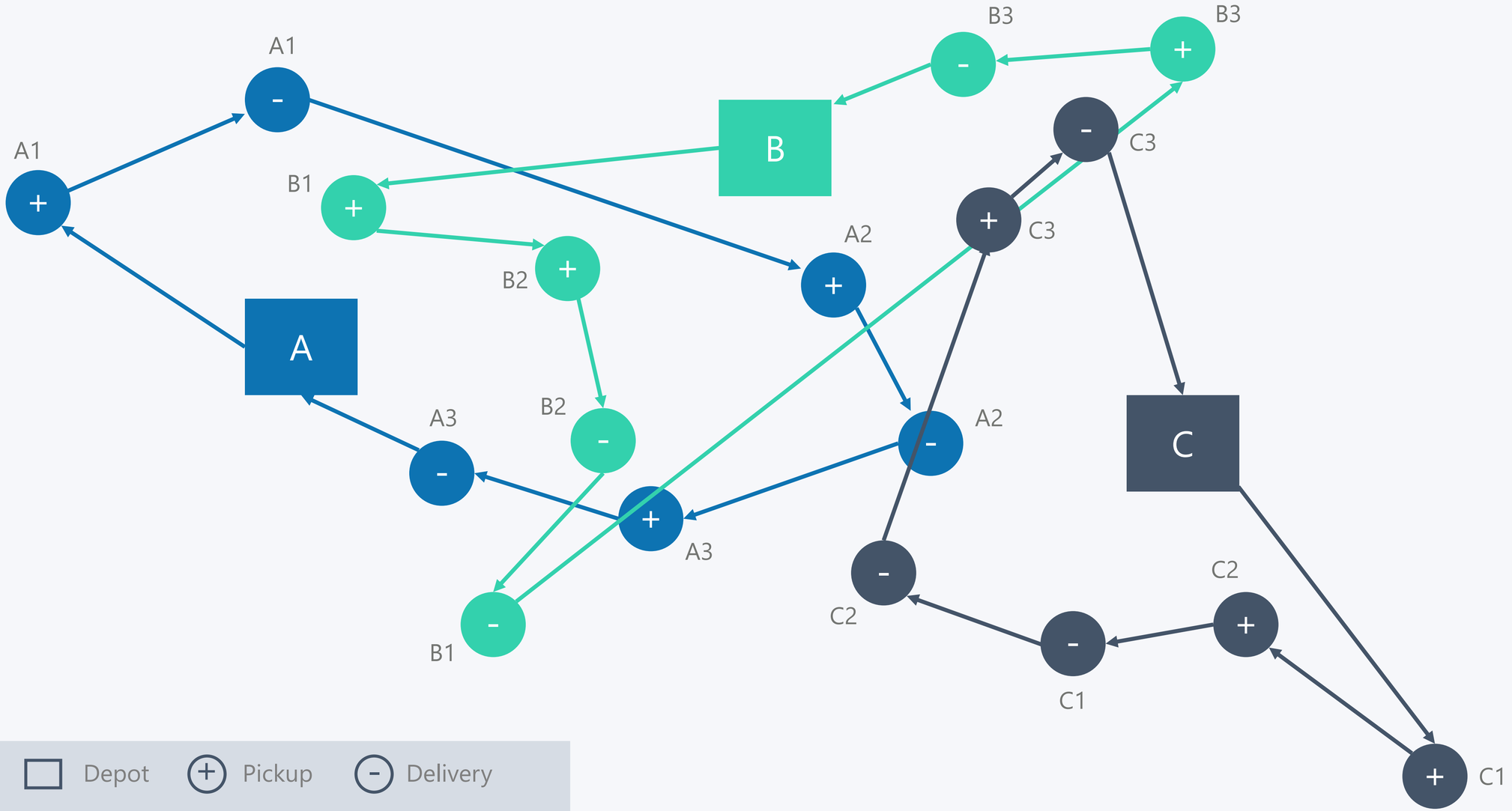

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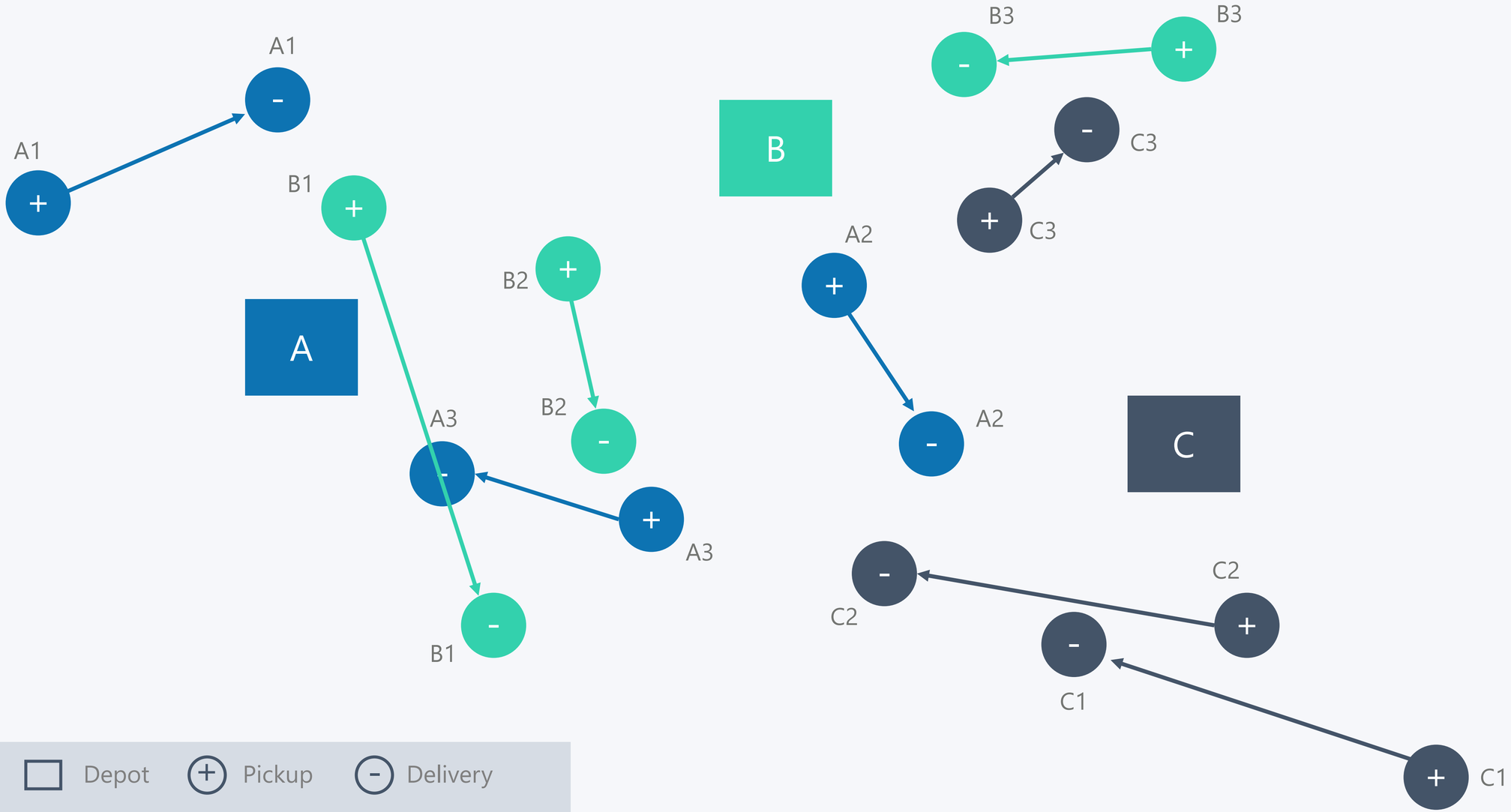
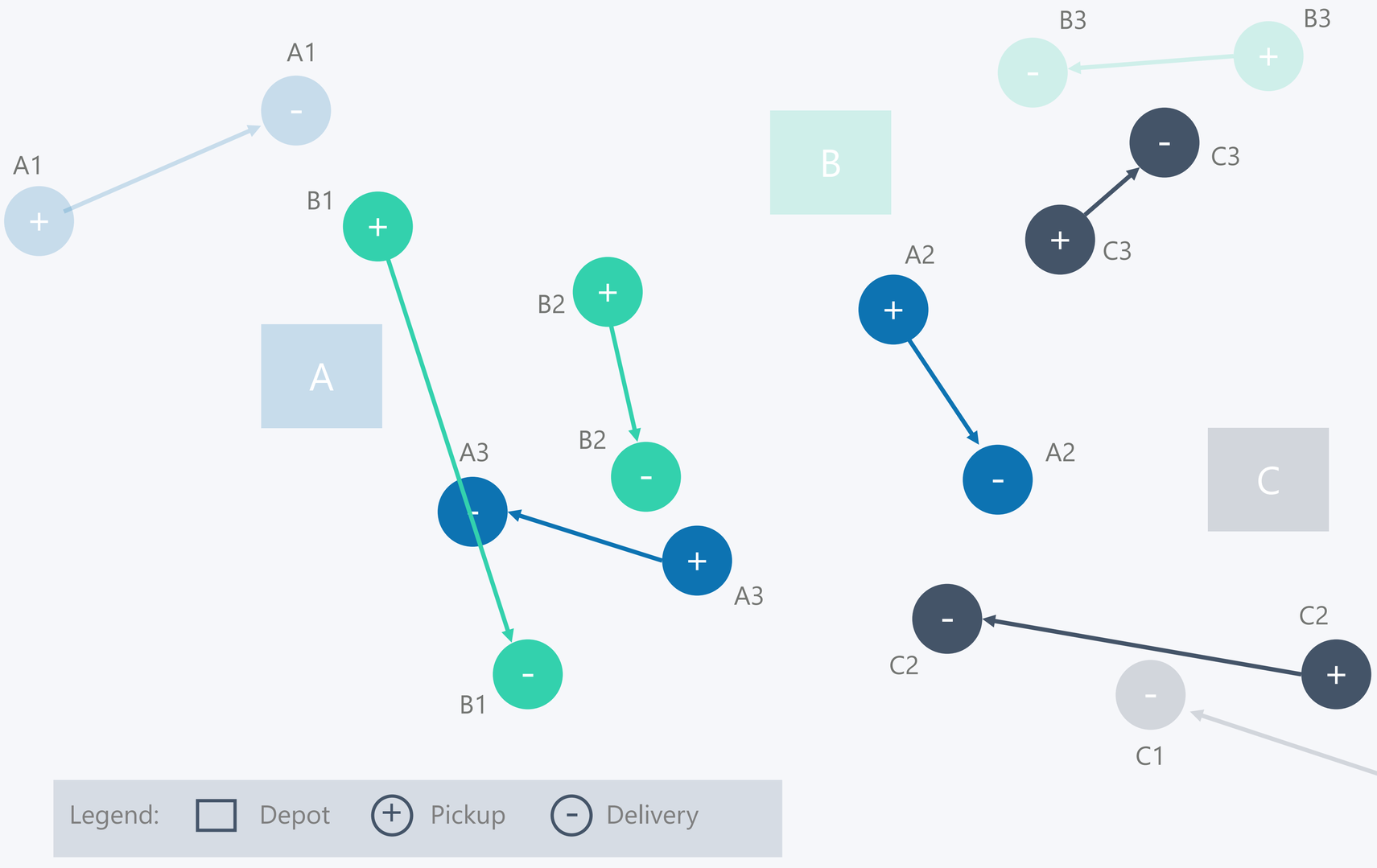


Request Selection - Carriers



Request Selection

Example Input Bids:

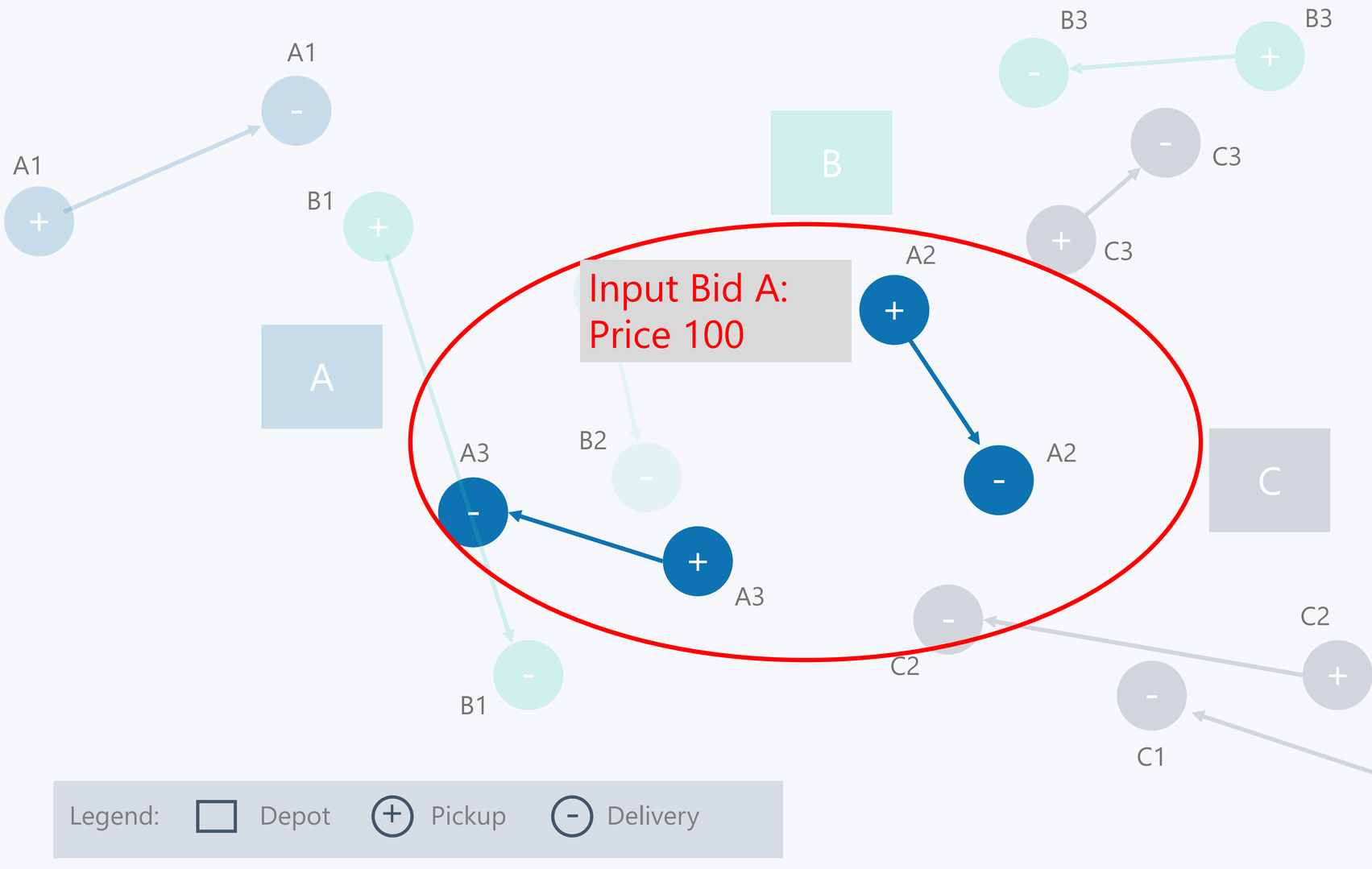
Carrier A
Input Bid = (A2, A3) with price 100

Carrier B:
Input Bid = (B1, B2) with price 130

Carrier C:
Input Bid = (C2, C3) with price 90

Legend: Depot Pickup Delivery

Request Selection - Carriers



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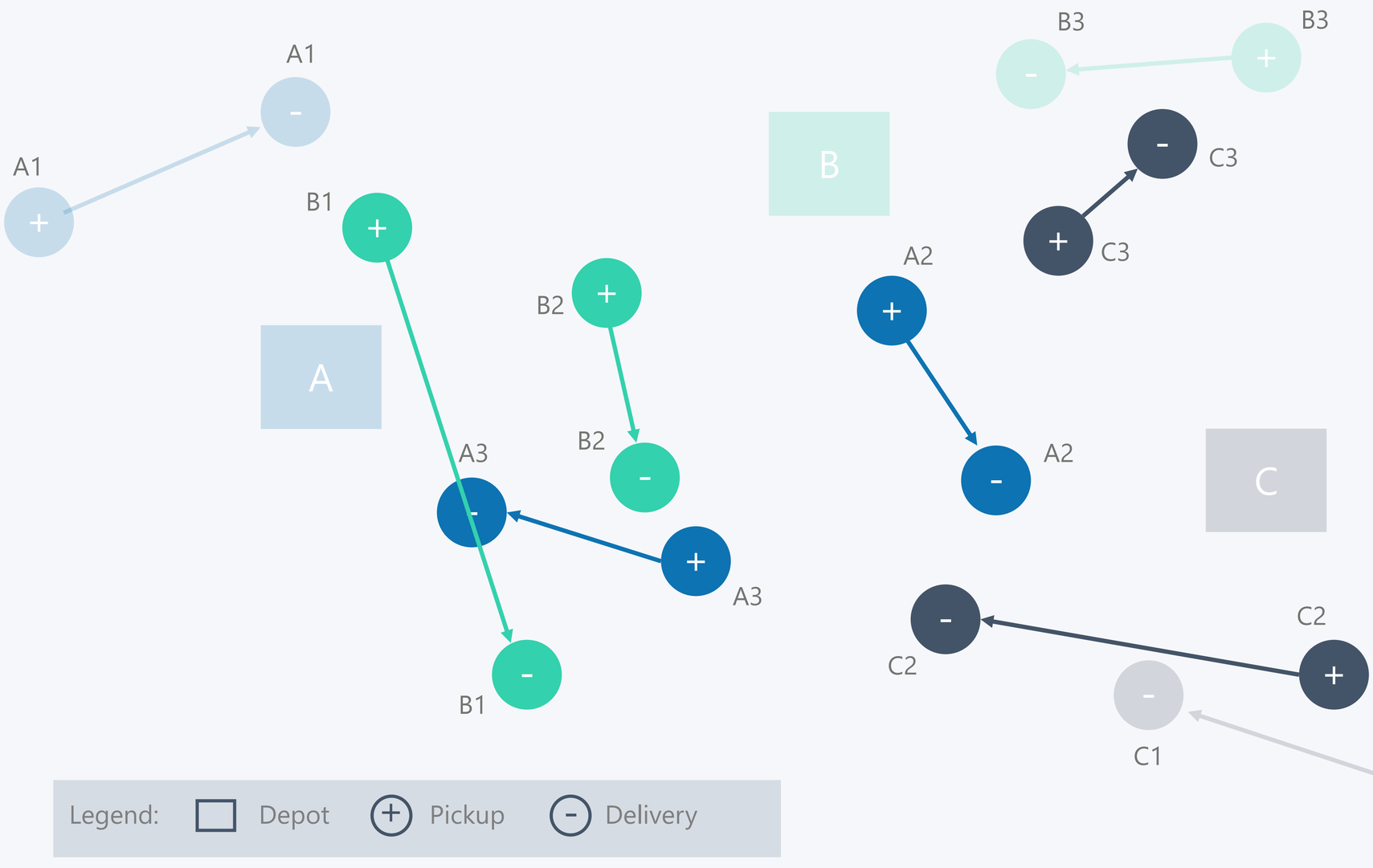
Bundle Generation – Mechanism Manager



Legend: Depot Pickup Delivery

Bundle Generation

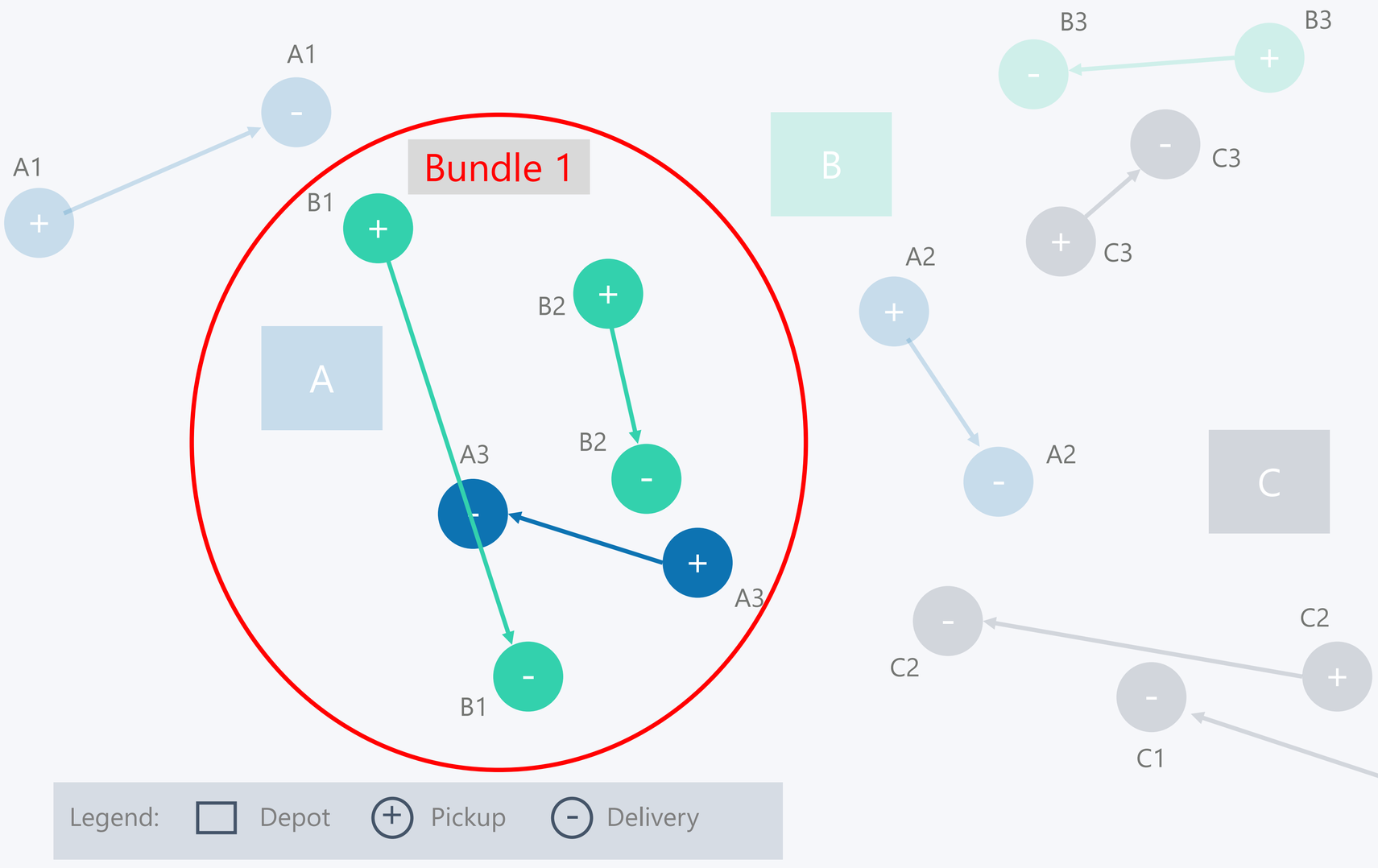
Example Bundles:

Bundle 1: (B1, B2, A3)
Bundle 2: (A2, C3)
Bundle 3: (B1, A3)
Bundle 4: (C2)
Etc.

Challenge
$2^{(Number\ of\ Requests)} - 1$ possible bundles

Generating bundles is necessary because of synergy effects!

Bundle Generation – Mechanism Manager



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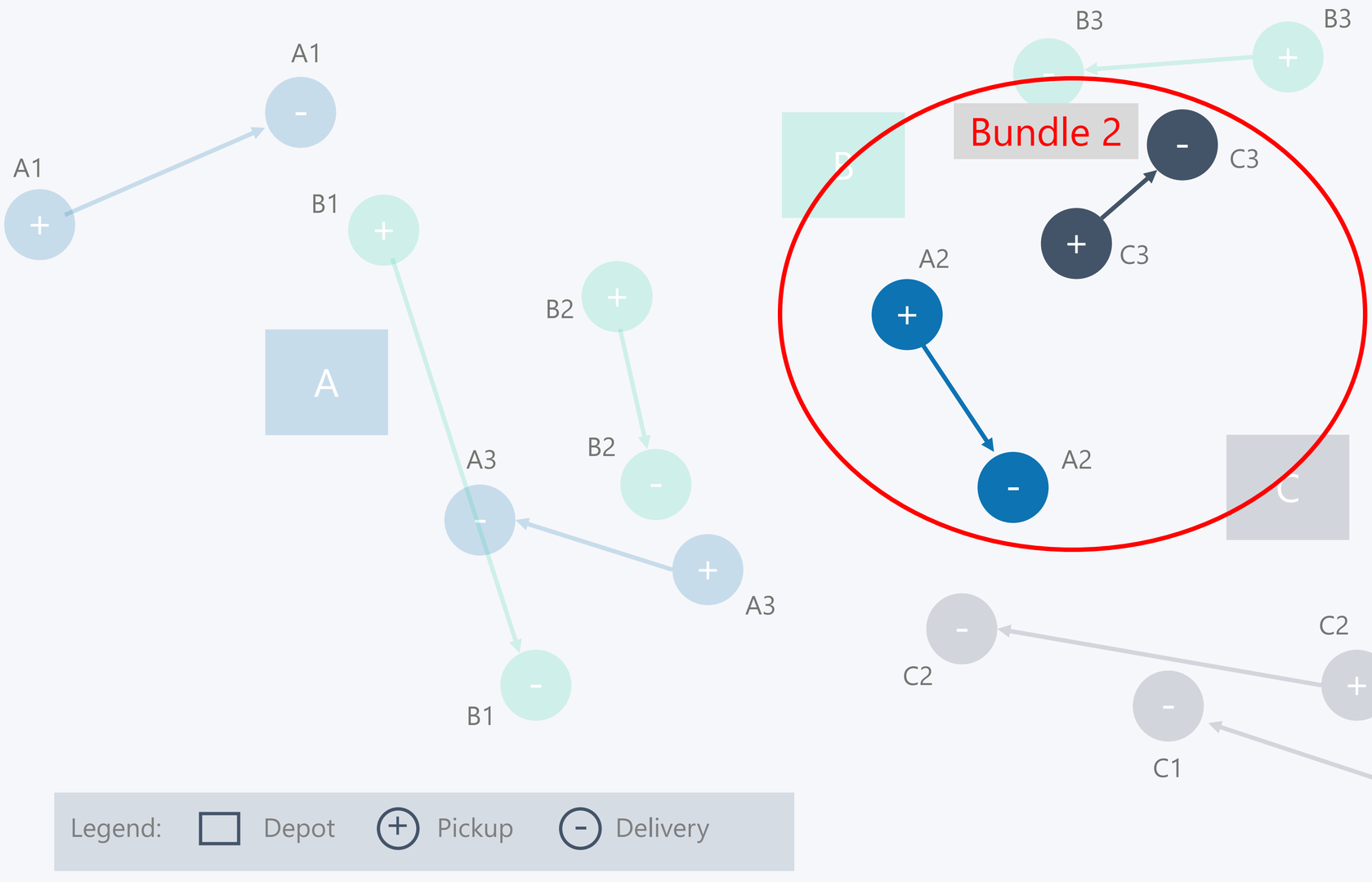

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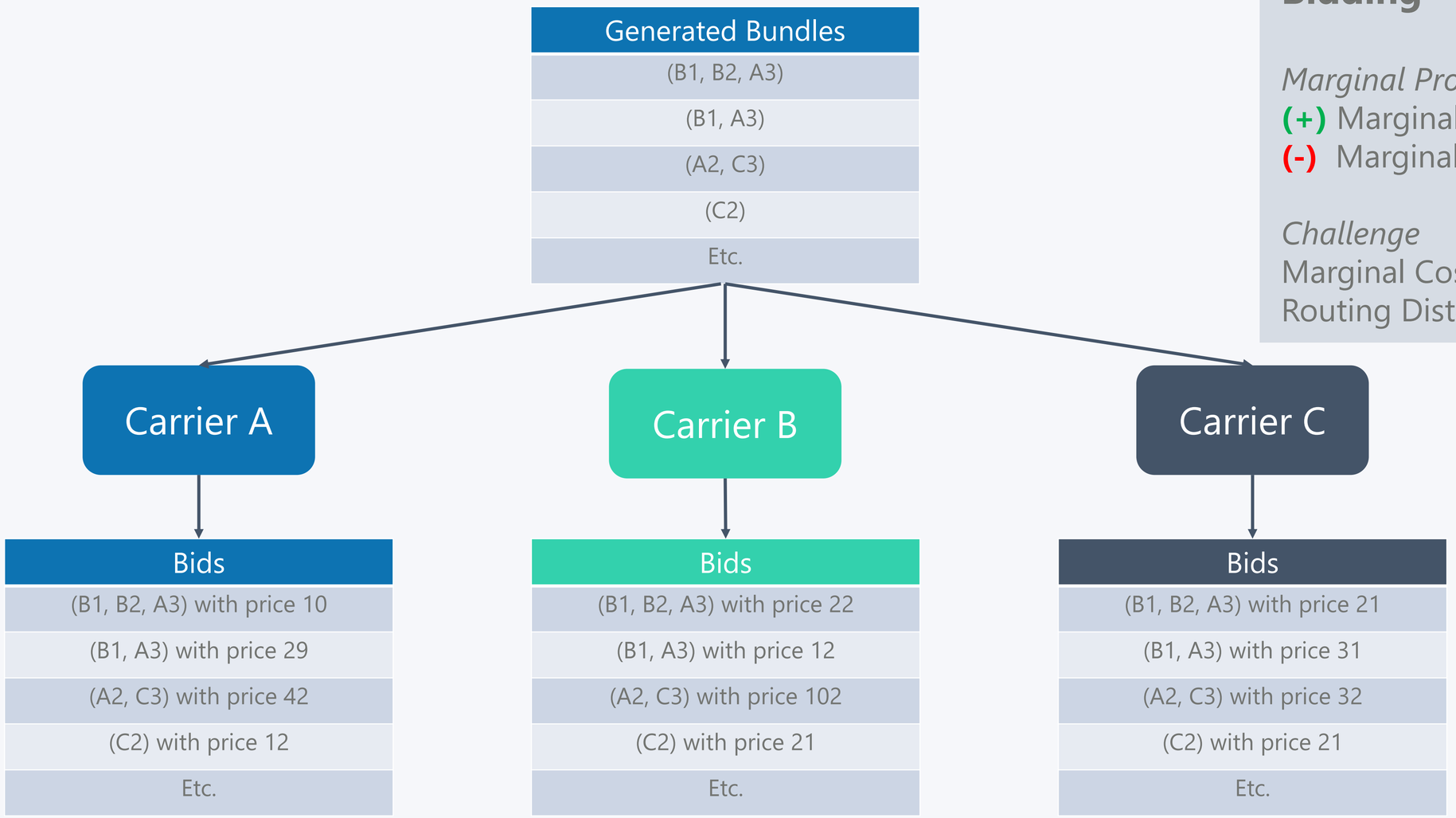
Bidding - Carriers

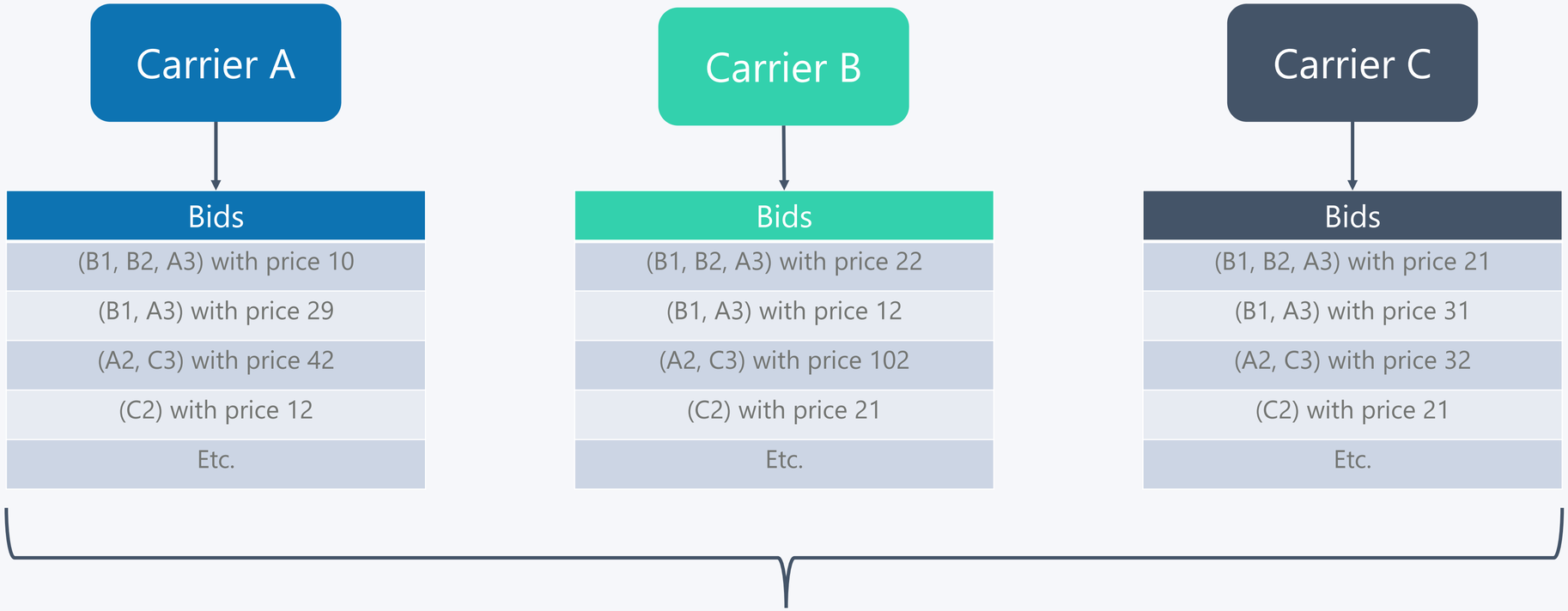


Bidding

Marginal Profit of Bundle
(+) Marginal Revenue
(-) Marginal Cost

Challenge
Marginal Cost depend on Marginal Routing Distance (hard to compute!)

Winner Determination – Mechanism Manager



Winner Determination

Objective: *Maximize total valuation of bids*
Constraint 1: *Each carrier wins at most one bid*
Constraint 2: *Each request is part of exactly one winning bid*

Payment Calculation – Mechanism Manager

Winner Determination

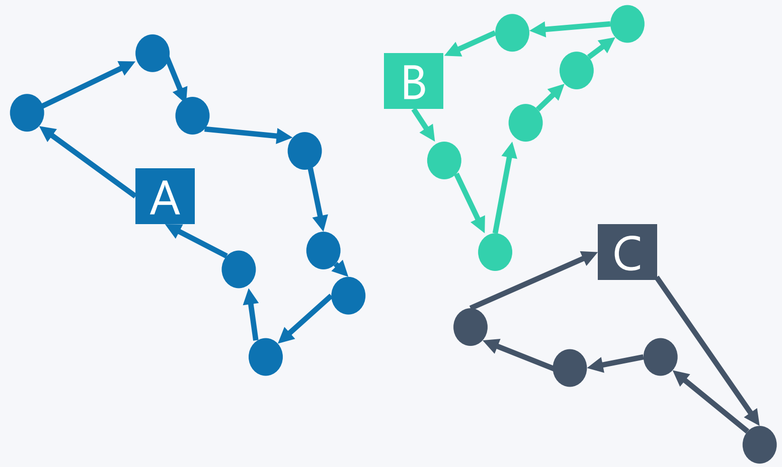
Objective: *Maximize total valuation of bids*
Constraint 1: *Each carrier wins at most one bid*
Constraint 2: *Each request is part of exactly one winning bid*

Request Allocation

If (total valuation of winning bids > total valuation of input bids):
→ allocate requests according to the winning bids
Else:
→ Stop mechanism or go back to Request Selection

Payment Calculation

Final Question: Who has to pay/gets paid (subject of next chapter)



?

Setup – Auction-based Mechanism

Request Selection	Bundle Generation	Bidding	Winner Determination	Payment Calculation
Requests selected based on: - Marginal profit - Distance to one's own depot - Distance to another carrier's depot - Closeness between each other → Input Bid *See [2]*	All possible bundles of requests are offered *Alternative:* Genetic Algorithm which selects the most attractive bundles (not used for tests) *Challenge:* - High synergy effects - Many possible bundles *See [3]*	Requires the carriers to calculate their marginal profit for each bundle *Marginal Profit:* (+) Revenues of requests in the bundle (-) Marginal cost of including the bundle in route *Routing Calculation:* Double Insertion with 3-opt (initial) or 2-opt improvement *Strategies:* Truthful, Conspiring, Strategic *See [11]*	A candidate is a set of bids whereas each request has to be allocated to exactly one carrier Winning Candidate = Most valuable Candidate Optimization program: Set partitioning problem (solved optimally with Google OR-Tools) *See [1]*	Different Payment Approaches: - Egalitarian - Purchase/Sale Weights - Shapley Value - Critical Weight (explained later)

Setup – Auction-based Mechanism

Request Selection

Requests selected based on:

- Marginal profit
- Distance to one's own depot
- Distance to another carrier's depot
- Closeness between each other

→ Input Bid

See [2]

Bundle Generation

All possible bundles of requests are offered

Alternative:
Genetic Algorithm which selects the most attractive bundles (not used for tests)

Challenge:
- High synergy effects
- Many possible bundles

See [3]

Bidding

Requires the carriers to calculate their marginal profit for each bundle

Marginal Profit:
(+) Revenues of requests in the bundle
(-) Marginal cost of including the bundle in route

Routing Calculation:
Double Insertion with 3-opt (initial) or 2-opt improvement

Strategies:
Truthful, Conspiring, Strategic

See [11]

Winner Determination

A candidate is a set of bids whereas each request has to be allocated to exactly one carrier

Winning Candidate = Most valuable Candidate

Optimization program:
Set partitioning problem
(solved optimally with Google OR-Tools)

See [1]

Payment Calculation

Different Payment Approaches:

- Egalitarian
- Purchase/Sale Weights
- Shapley Value
- Critical Weight

(explained later)

Setup – Auction-based Mechanism

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Setup – Auction-based Mechanism

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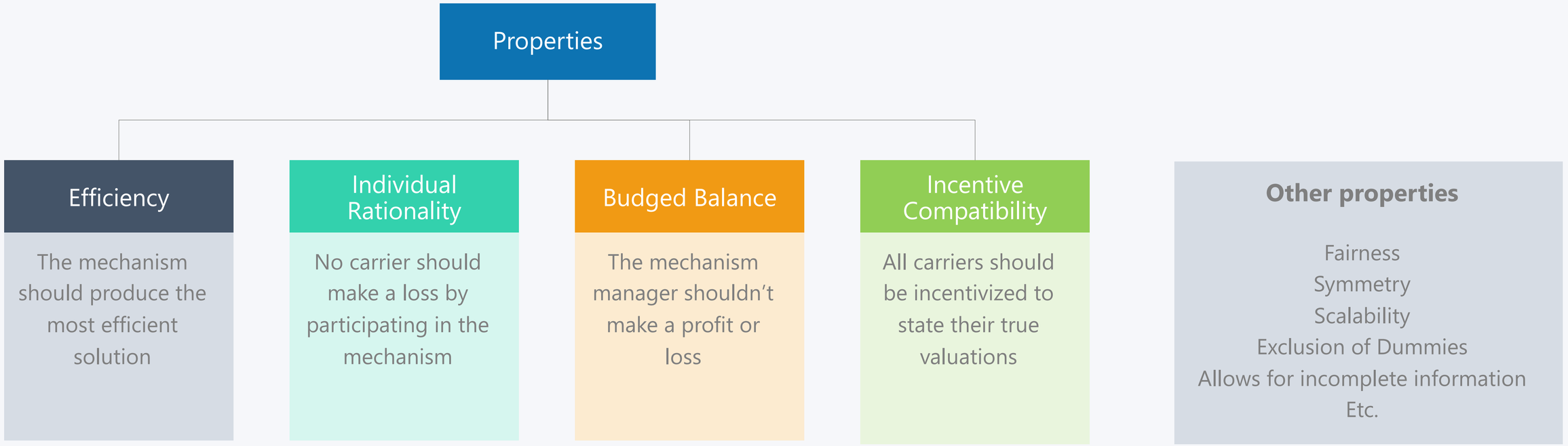
See [2]

4.2 Bidding Strategies for Modified Egalitarian Profit Sharing

Desirable Properties



See [6]

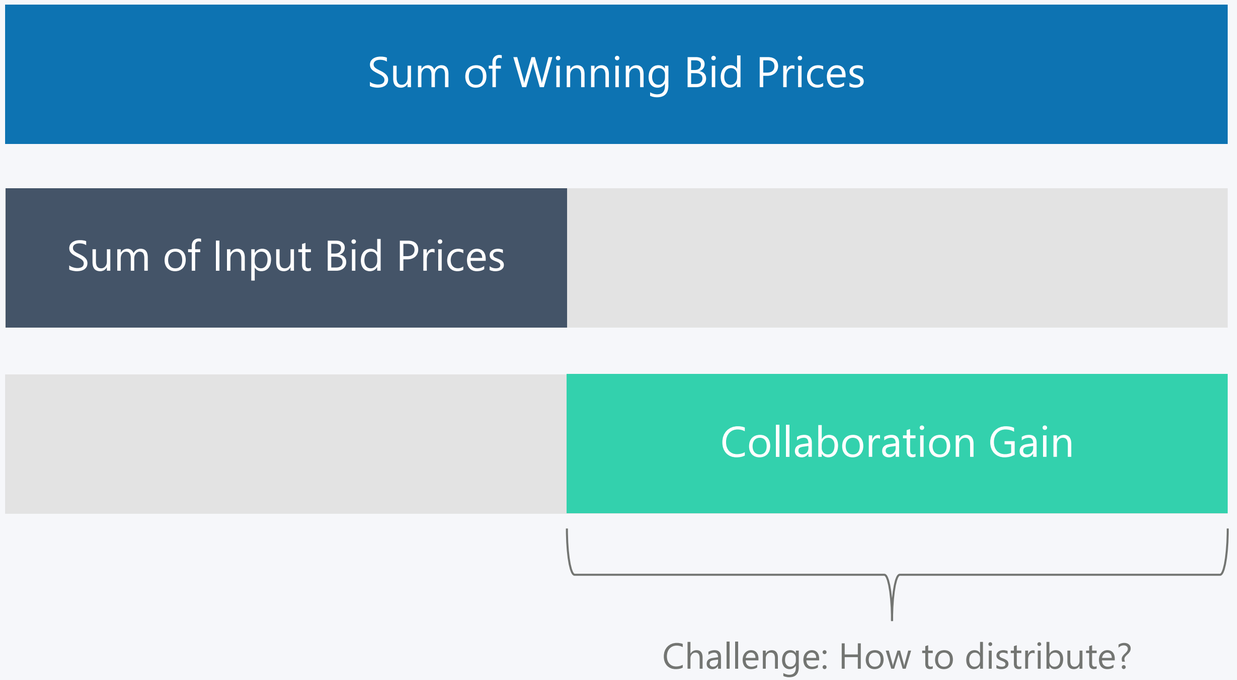
e.g., see [9], [11]

Problem: Not all properties can be achieved simultaneously

3 Payment Calculation and Profit Sharing Methods in Auction-based Transport Collaborations

Generic Payment Method

1. **Collect** the money from all carriers who won a bid (on a bundle of requests)
2. **Pay** every carrier her/his valuation of her/his offered requests (Input Bid)
3. **Share** the remaining collaboration gain between the carriers



Guaranteed Properties: Individual Rationality; Budget Balance

Challenge: Incentive Compatibility or rather the mitigation of strategic manipulation

Analyzed Profit Sharing Methods

Profit Sharing Methods

Egalitarian	Purchase/Sale Weights	Shapley Value	Critical Weight
Methods that, in principle, share the collaboration gain equally between carriers	Methods that consider the carrier's price of her/his input and winning bids	Method that distributes the collaboration gain according to the well-known Shapley Value	Method that distributes the collaboration according to a "critical weight" which is linked to the concept of VCG-Payments
See [4]	*See [5]*	*See [11]*	

4 Strategic Manipulation of Bids in Auction-based Transport Collaborations

Different Bidders for Evaluation

Truthful Bidders

Always bid truthfully their valuations

→ Used to **evaluate** the **truthful outcome** of the mechanism

→ Help to **evaluate** the strategic potential of a **single strategic/conspiring carrier**

Conspiring Bidders

Receive information about all bid prices
+
Use the information to manipulate their bid prices

→ Used to **evaluate** the **upside of strategic manipulation**

→ Help to get **insight** about the construction of **successful strategies**

Strategic Bidders

Manipulate their bid prices

→ Used to **evaluate** the **potential of realistic strategic behavior**

→ Help to **estimate** the **likelihood** that **carriers will act strategically**

Tests Configuration

Property	Value
Number of carriers	3
Initial number of requests per carrier	9
Competition Level	Medium (see [2], “02”)
Number of traded requests per carrier (per mechanism round)	3
Number of instances per test	100
Max capacity of carrier	1,3x distance of initial routing solution
Min number of maintained requests per carrier	4
Number of retries of request selection (if no improvement)	2
Default bidding strategy	Truthful
Profitability	All Equal

4.1 Bidding Strategies for Egalitarian Profit Sharing

Egalitarian Profit Sharing

Profit Sharing Rule:

Share the collaboration gain equally between the carriers

See [4]

Perspective of Conspiring Bidder

Example

Each “Block” = Feasible Solution of WDP

→ **Ranking of Feasible Solutions**

Legend: Prices of BIDs

Perspective of Conspiring Bidder

Example

Each “Block” = Feasible Solution of WDP

Feasibility Constraints
1) Every carrier gets at most one bid
2) Every request is part of exactly one bid

Legend: Valuation of BIDs

Perspective of Conspiring Bidder

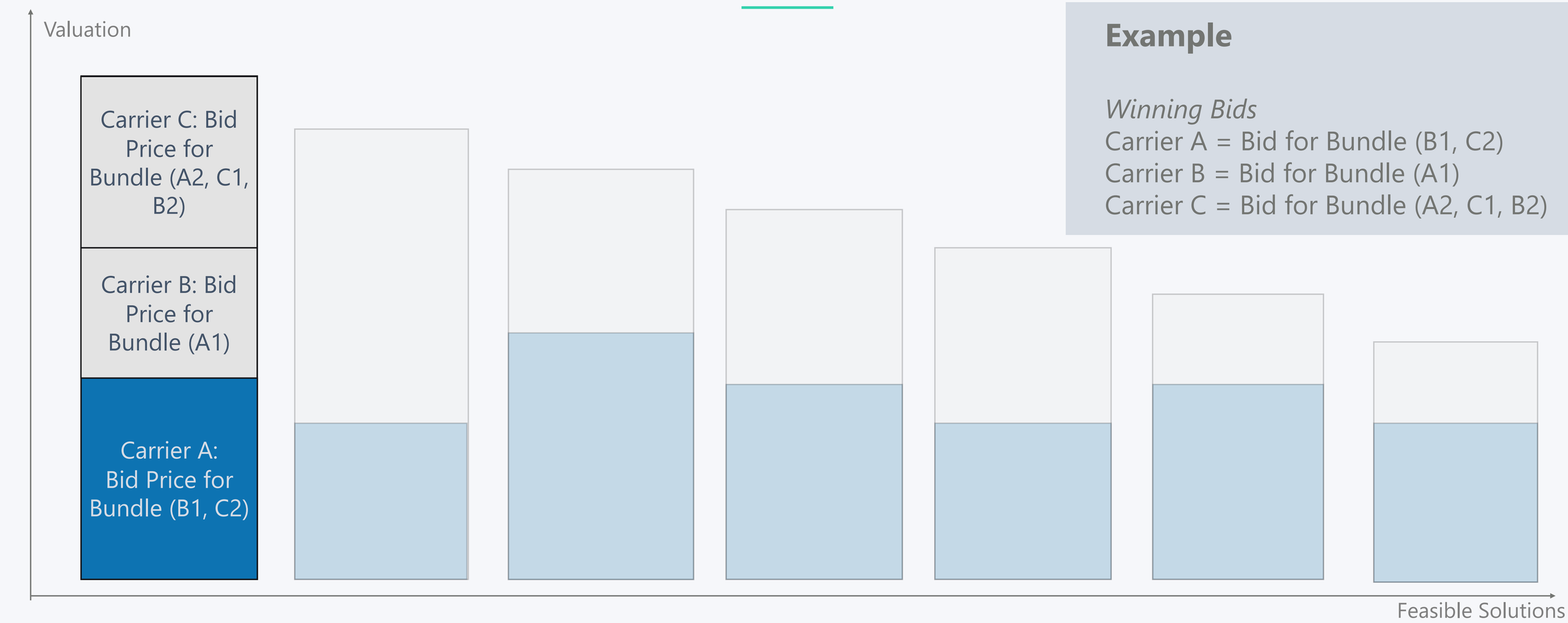
Example

Each “Block” = Feasible Solution of WDP

→ **Ranking of Feasible Solutions**

Legend: Valuation of BIDs

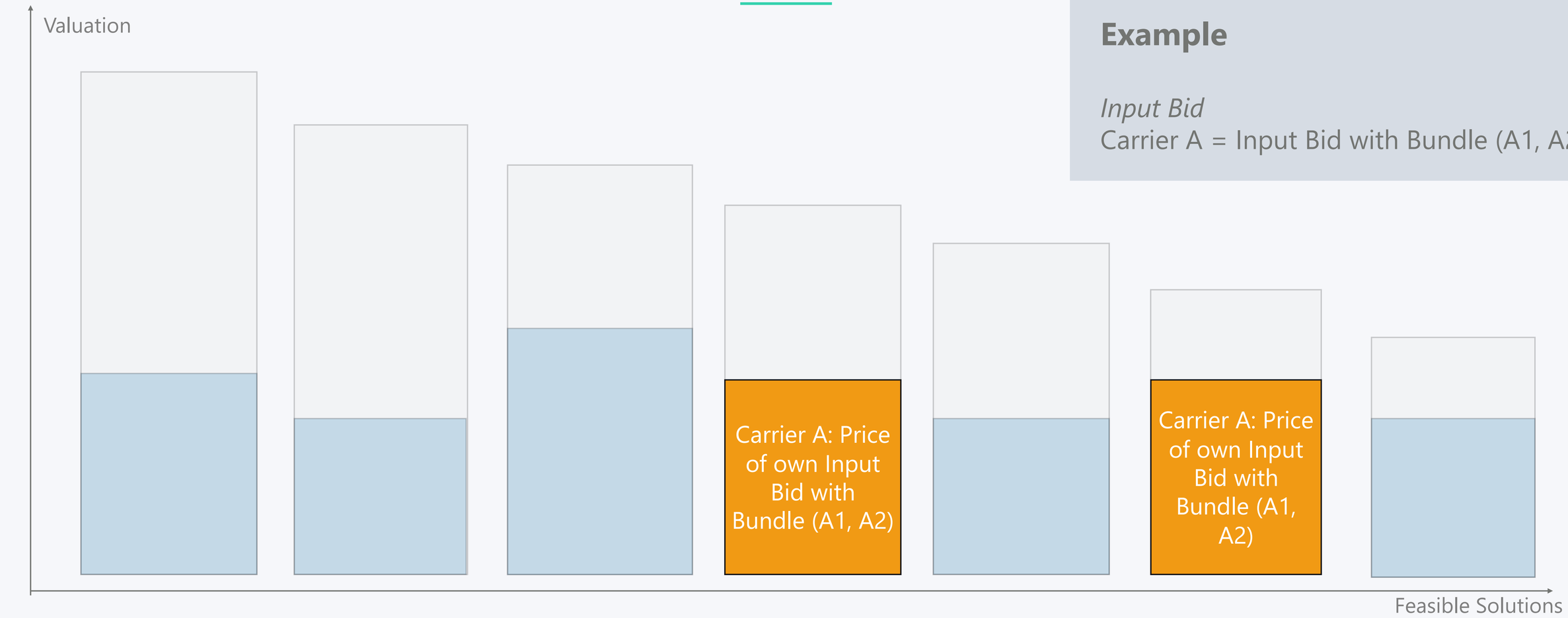
Perspective of Conspiring Bidder



Example

Winning Bids
Carrier A = Bid for Bundle (B1, C2)
Carrier B = Bid for Bundle (A1)
Carrier C = Bid for Bundle (A2, C1, B2)

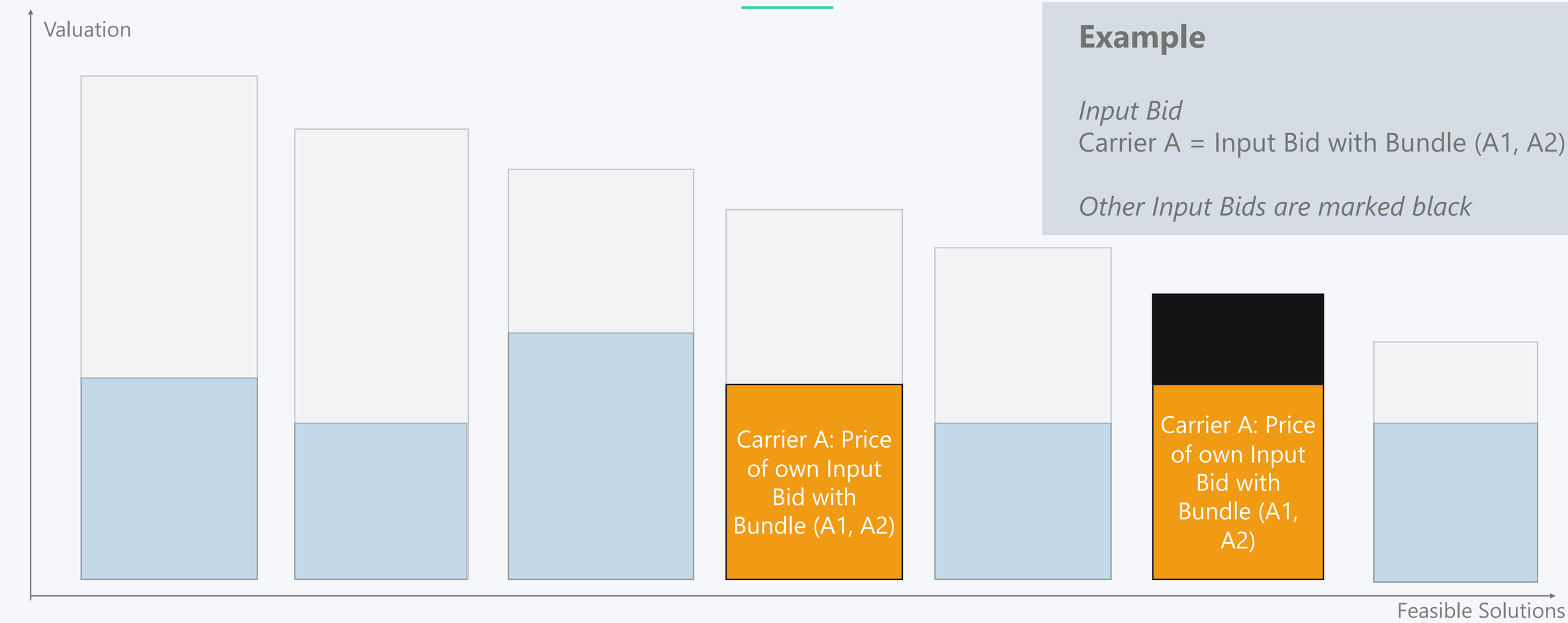
Perspective of Conspiring Bidder



Example

Input Bid
Carrier A = Input Bid with Bundle (A1, A2)

Perspective of Conspiring Bidder

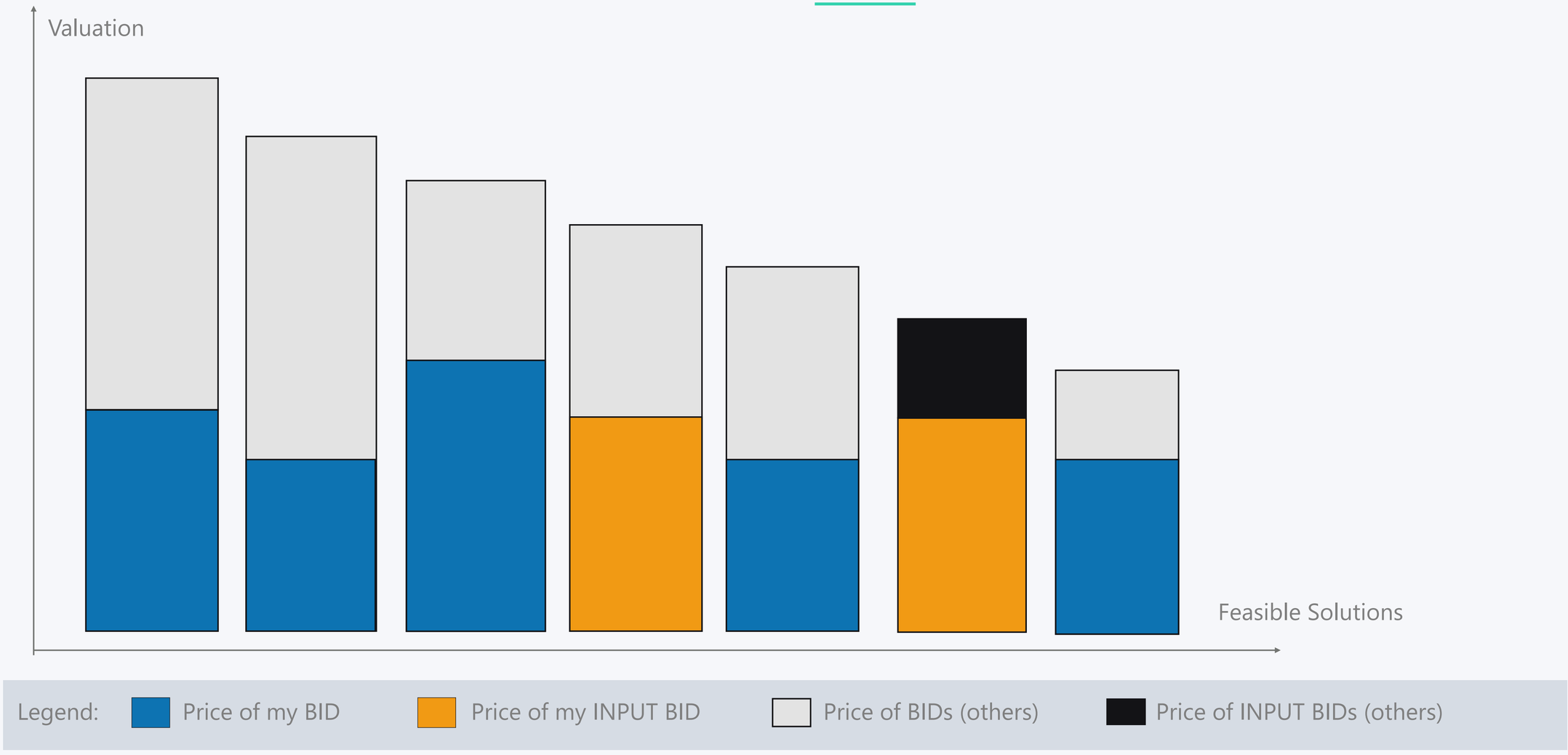


Example

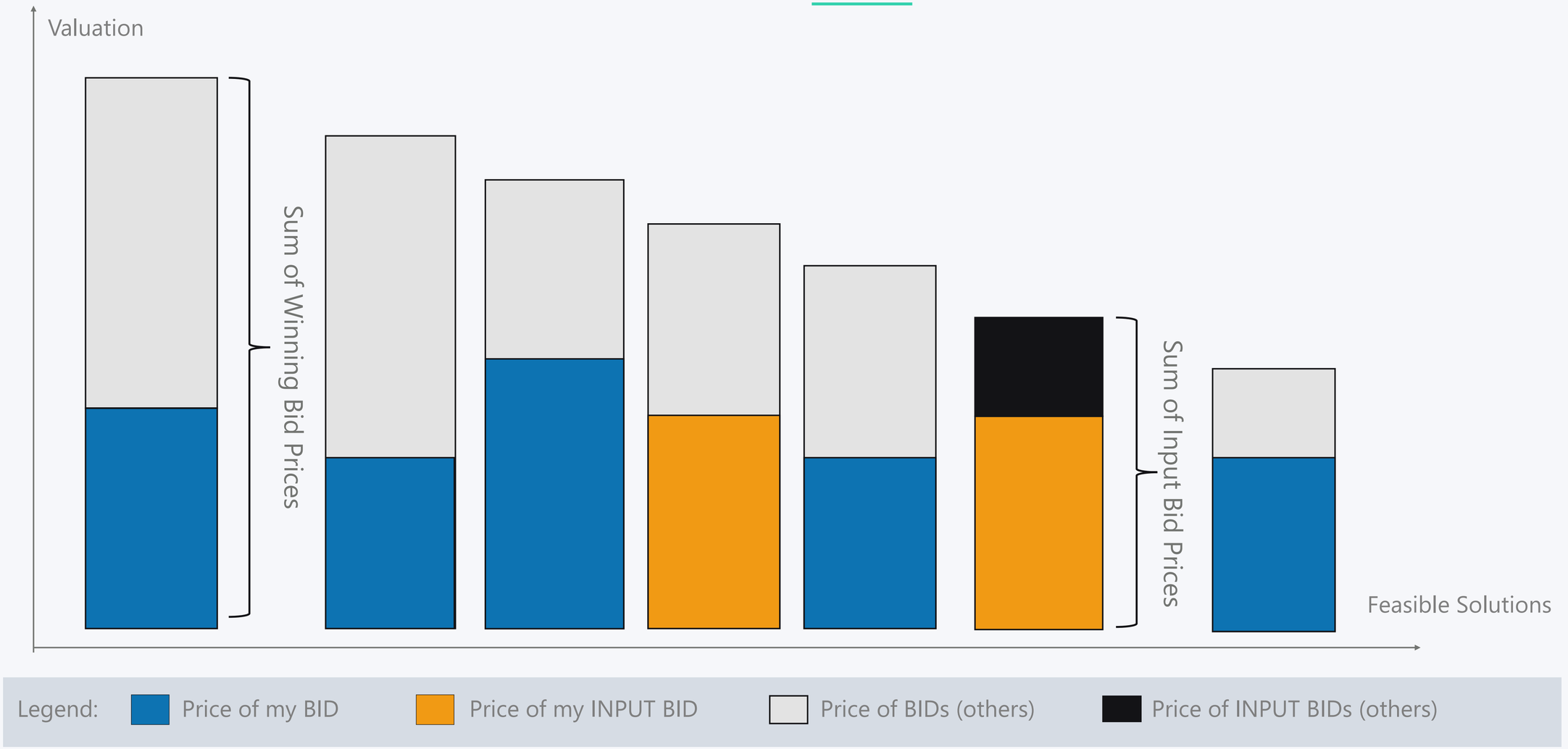
Input Bid
Carrier A = Input Bid with Bundle (A1, A2)

Other Input Bids are marked black

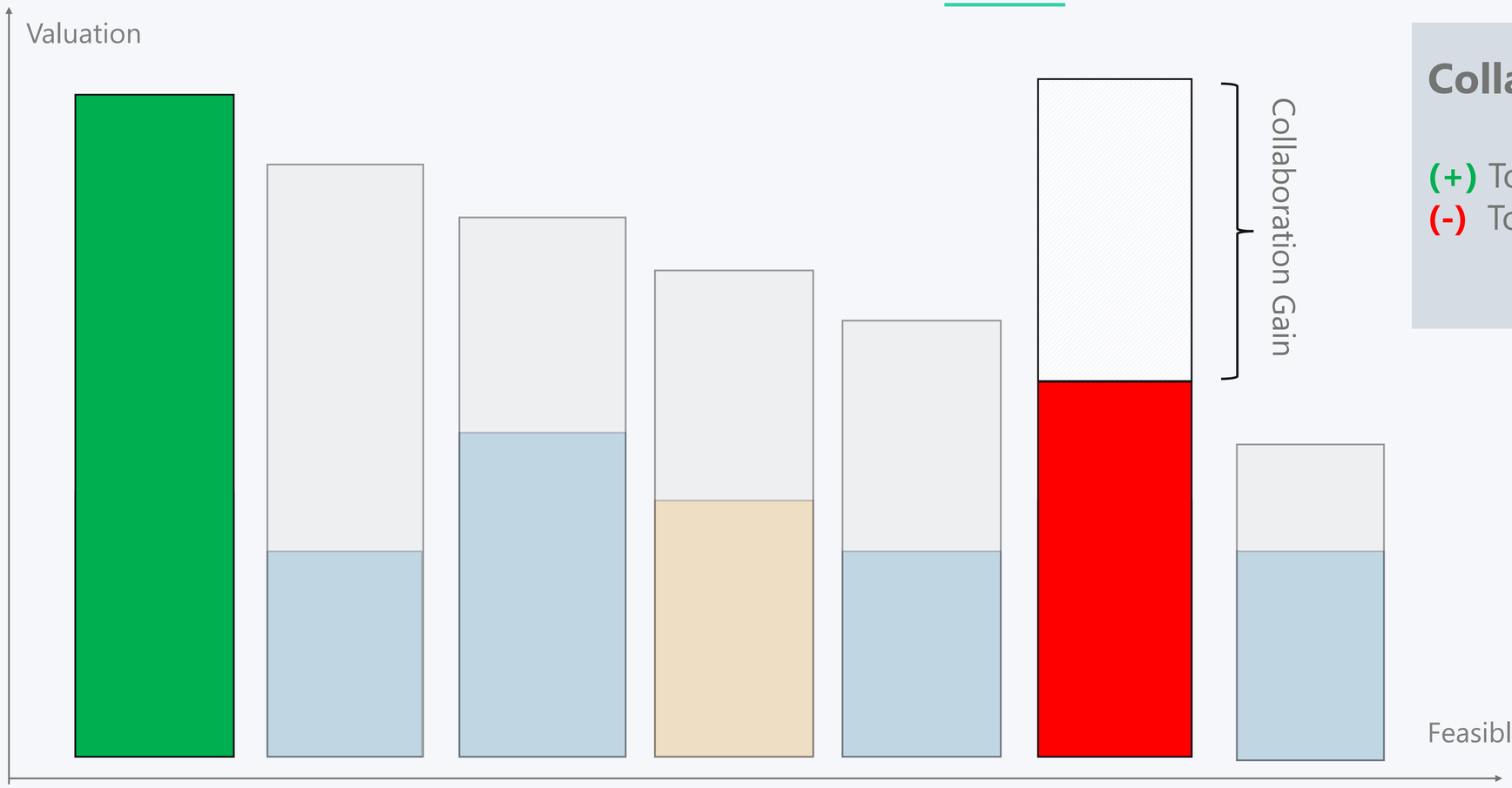
Perspective of Conspiring Bidder



Perspective of Conspiring Bidder



Perspective of Conspiring Bidder

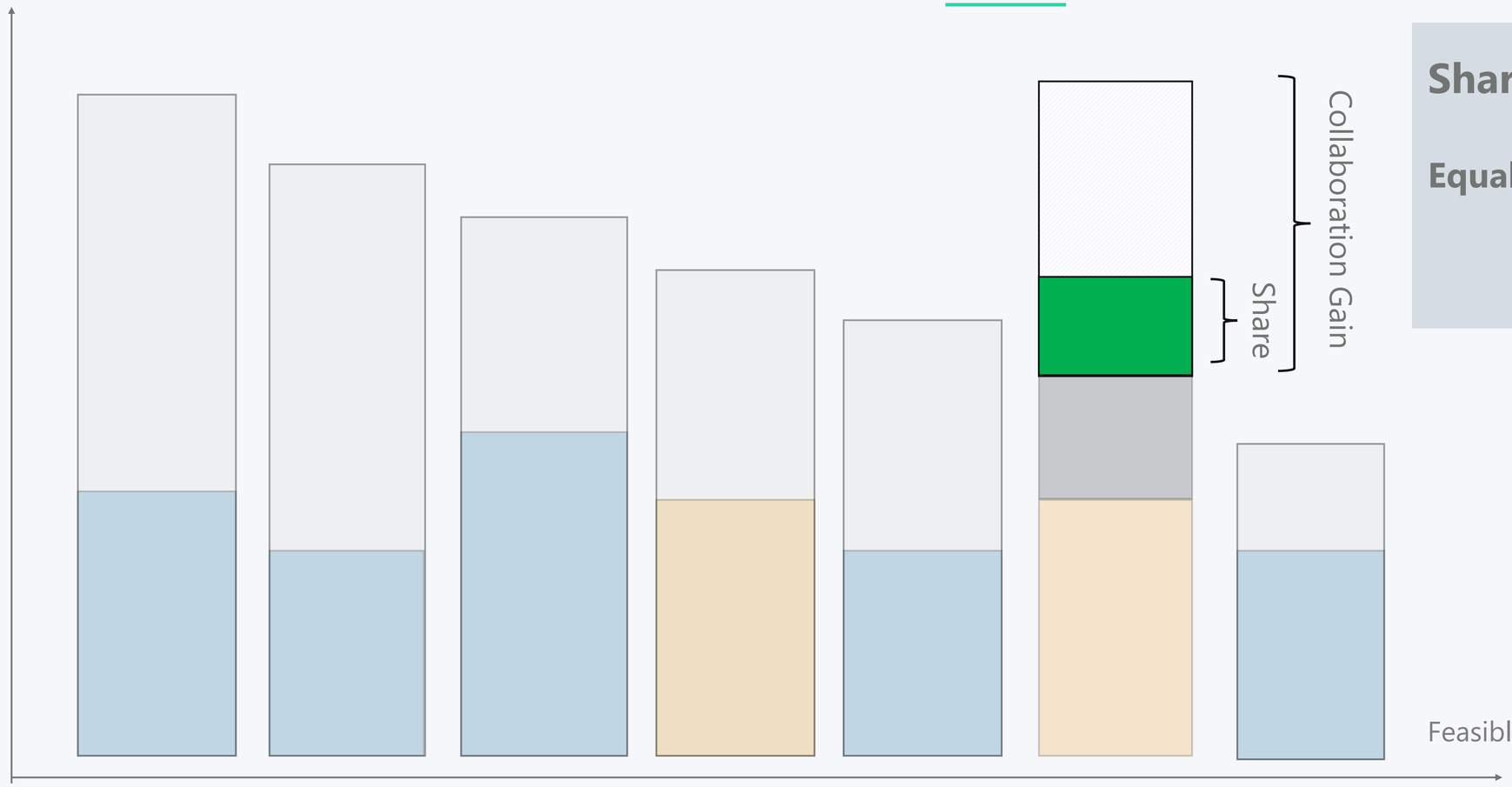


Collaboration Gain

(+) Total value of Winning Bid prices
(-) Total value of Input Bid prices

Legend: Price of my BID | Price of my INPUT BID | Price of BIDs (others) | Price of INPUT BIDs (others) | Gain | Loss

Perspective of Conspiring Bidder

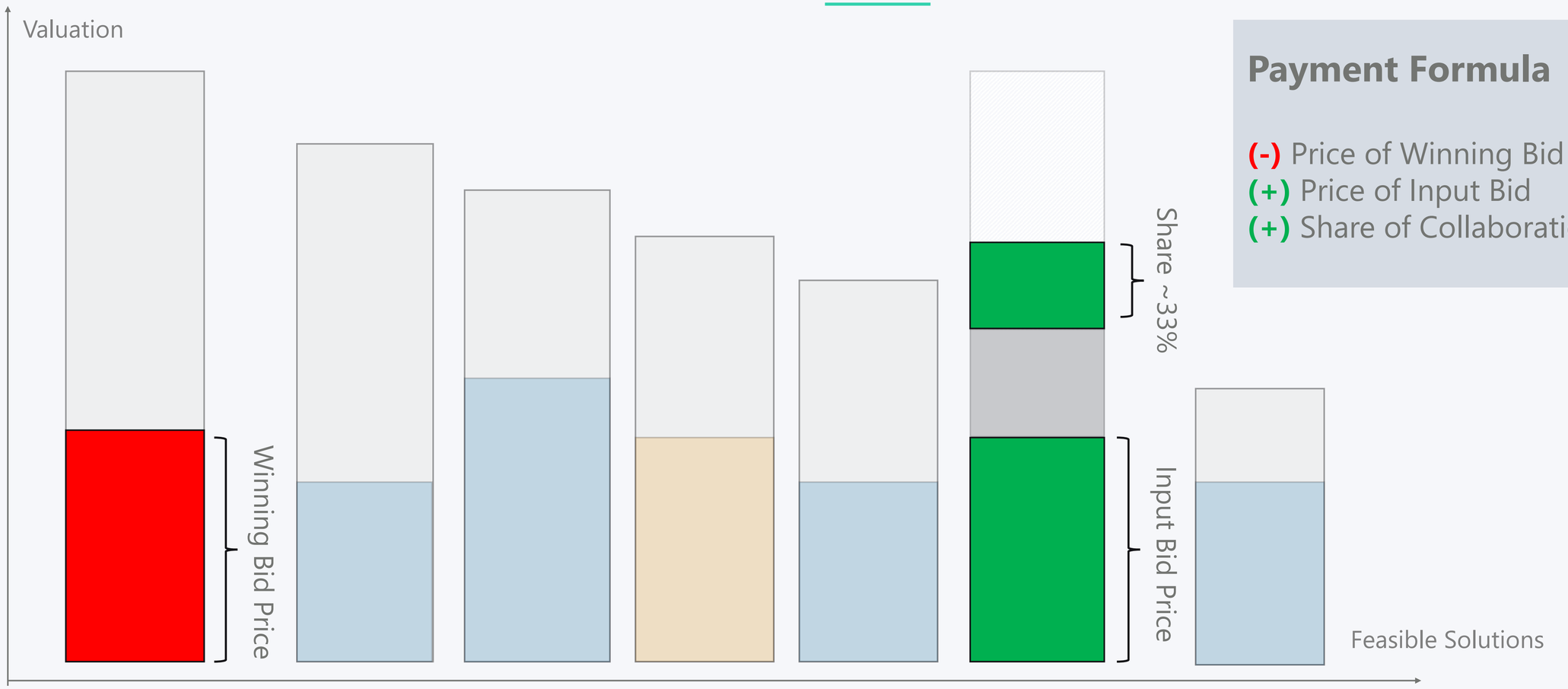


Share

Equal Share = 1 / (number of carriers)

Legend: Price of my BID | Price of my INPUT BID | Price of BIDs (others) | Price of INPUT BIDs (others) | Gain | Loss

Perspective of Conspiring Bidder

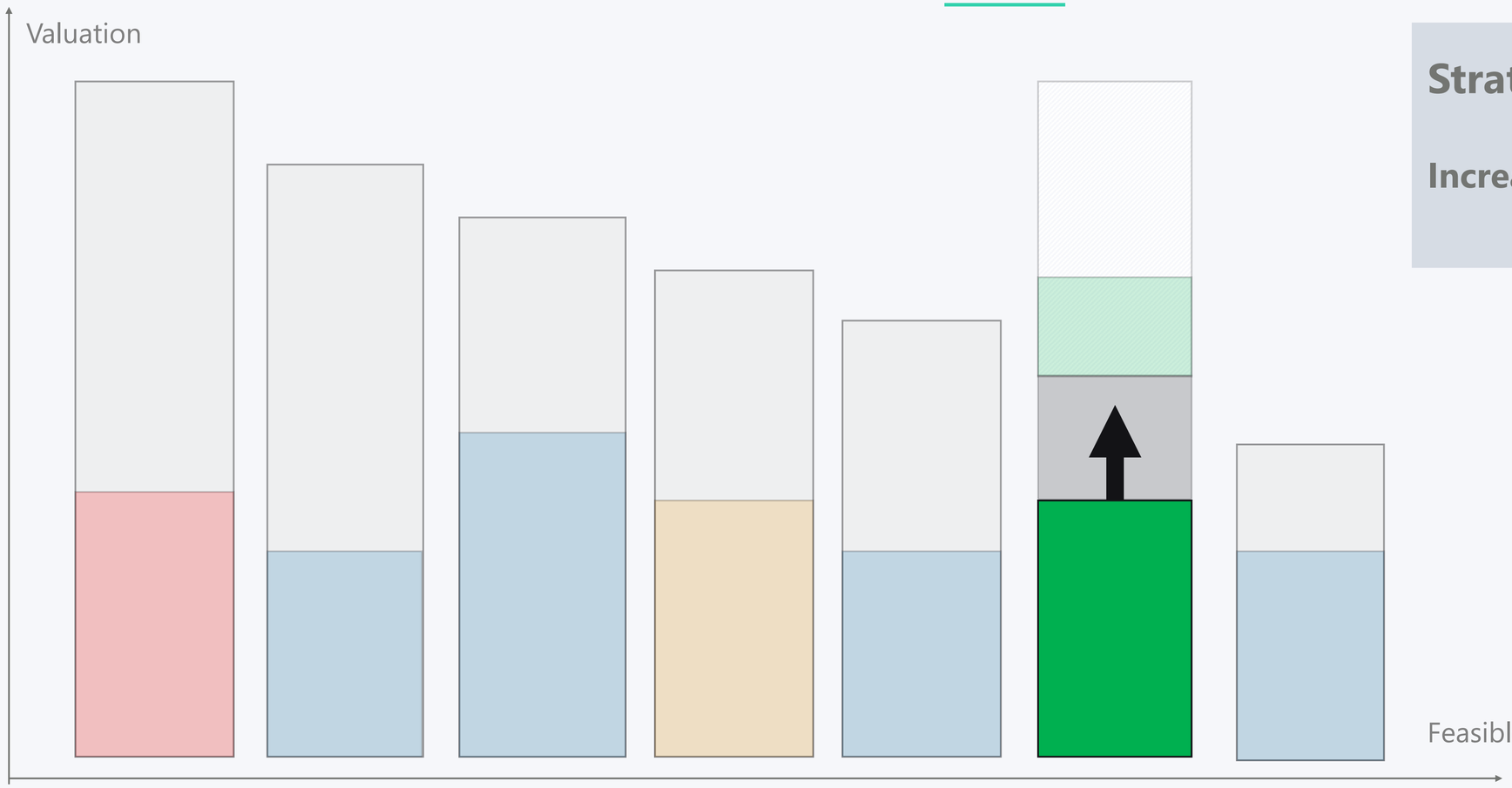


Payment Formula

(-) Price of Winning Bid
(+) Price of Input Bid
(+) Share of Collaboration Gain

Legend: Price of my BID; Price of my INPUT BID; Price of BIDs (others); Price of INPUT BIDs (others); Gain; Loss

Perspective of Conspiring Bidder

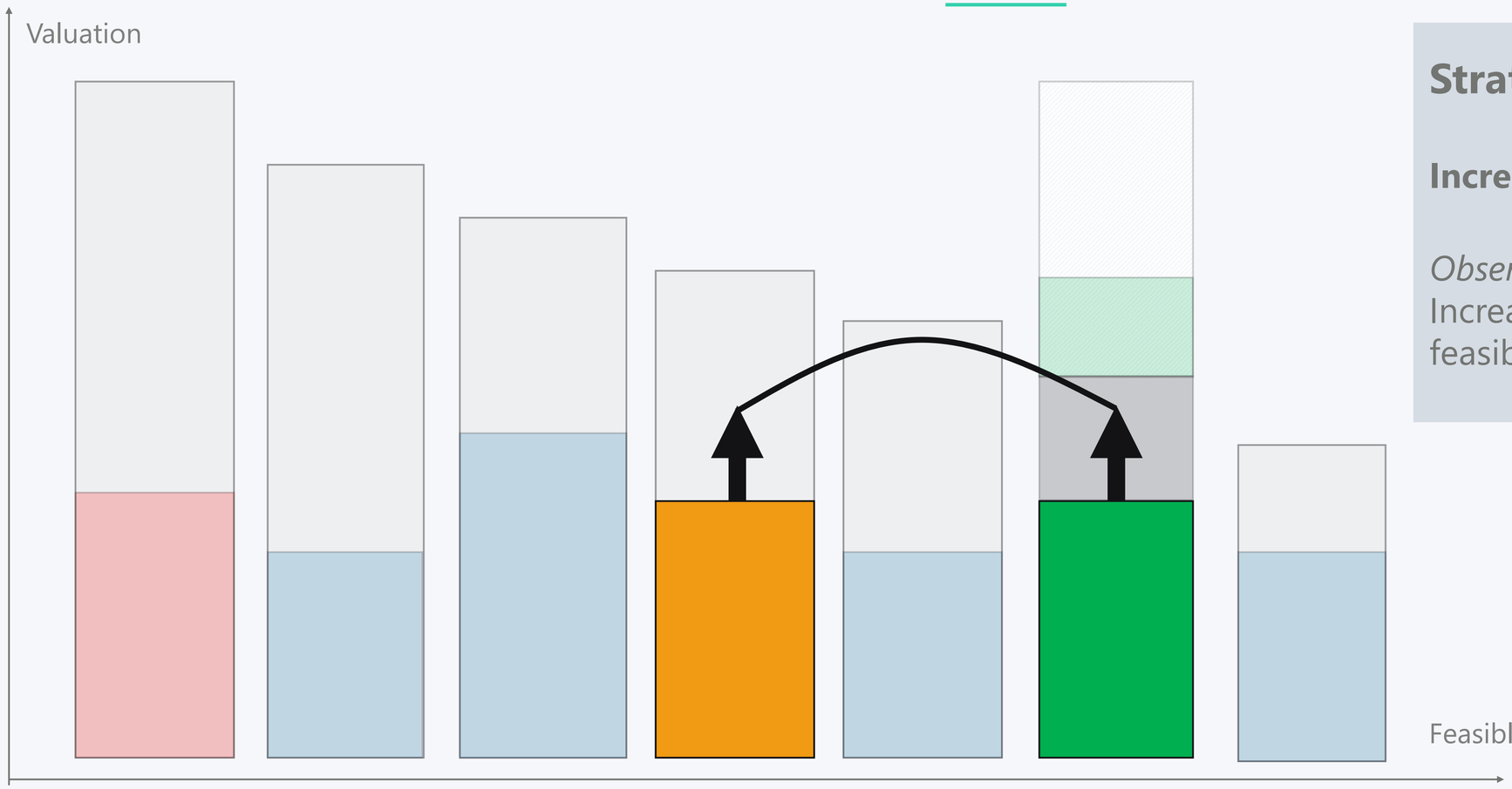


Strategy - INPUT_MAX

Increase price of Input Bid

Legend:
- Price of my BID
- Price of my INPUT BID
- Price of BIDs (others)
- Price of INPUT BIDs (others)
- Gain
- Loss

Perspective of Conspiring Bidder



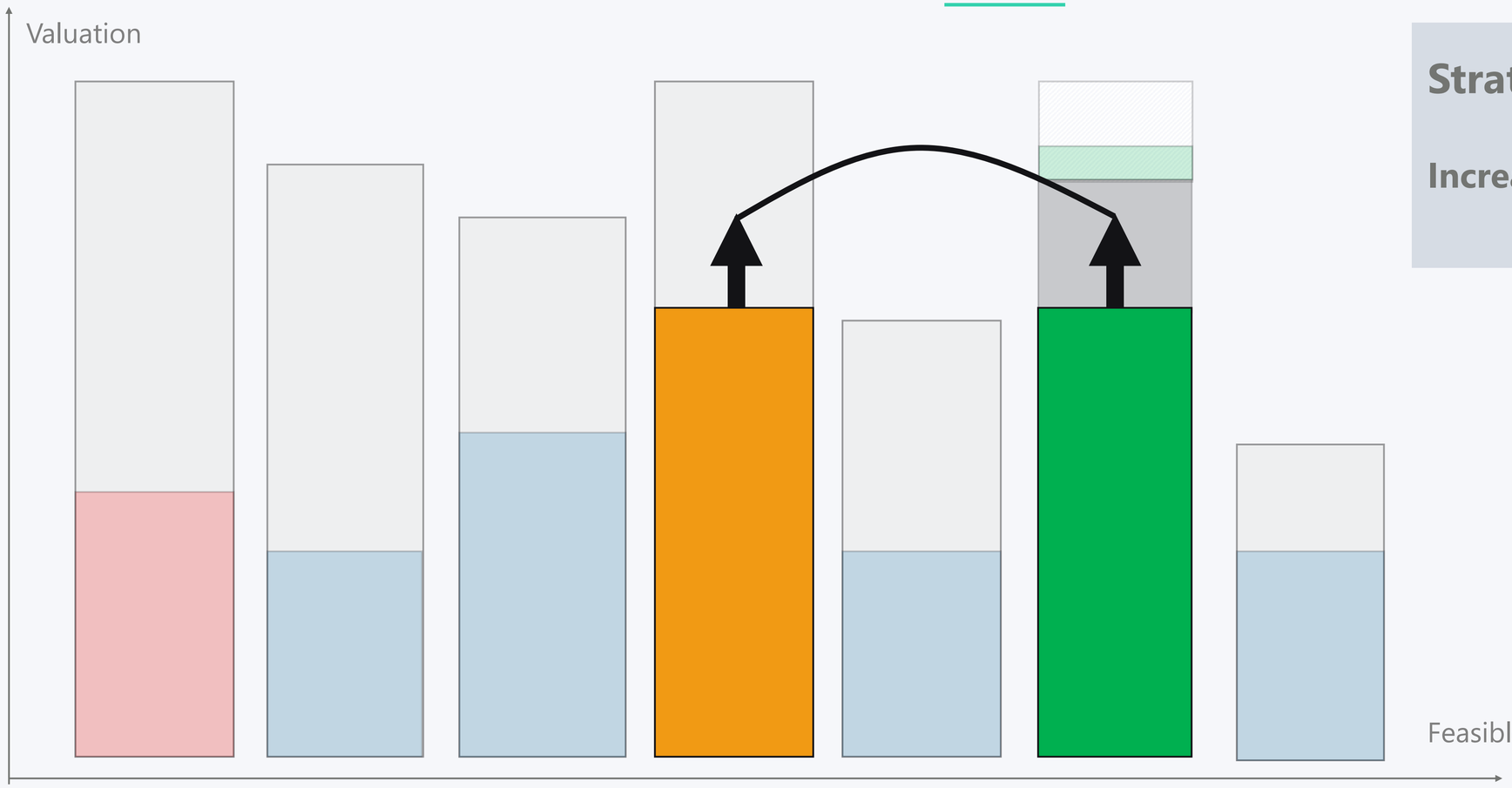
Strategy - INPUT_MAX

Increase price of Input Bid

Observation:
Increase in Input Bid price effects multiple feasible solutions

Legend: Price of my BID | Price of my INPUT BID | Price of BIDs (others) | Price of INPUT BIDs (others) | Gain | Loss

Perspective of Conspiring Bidder

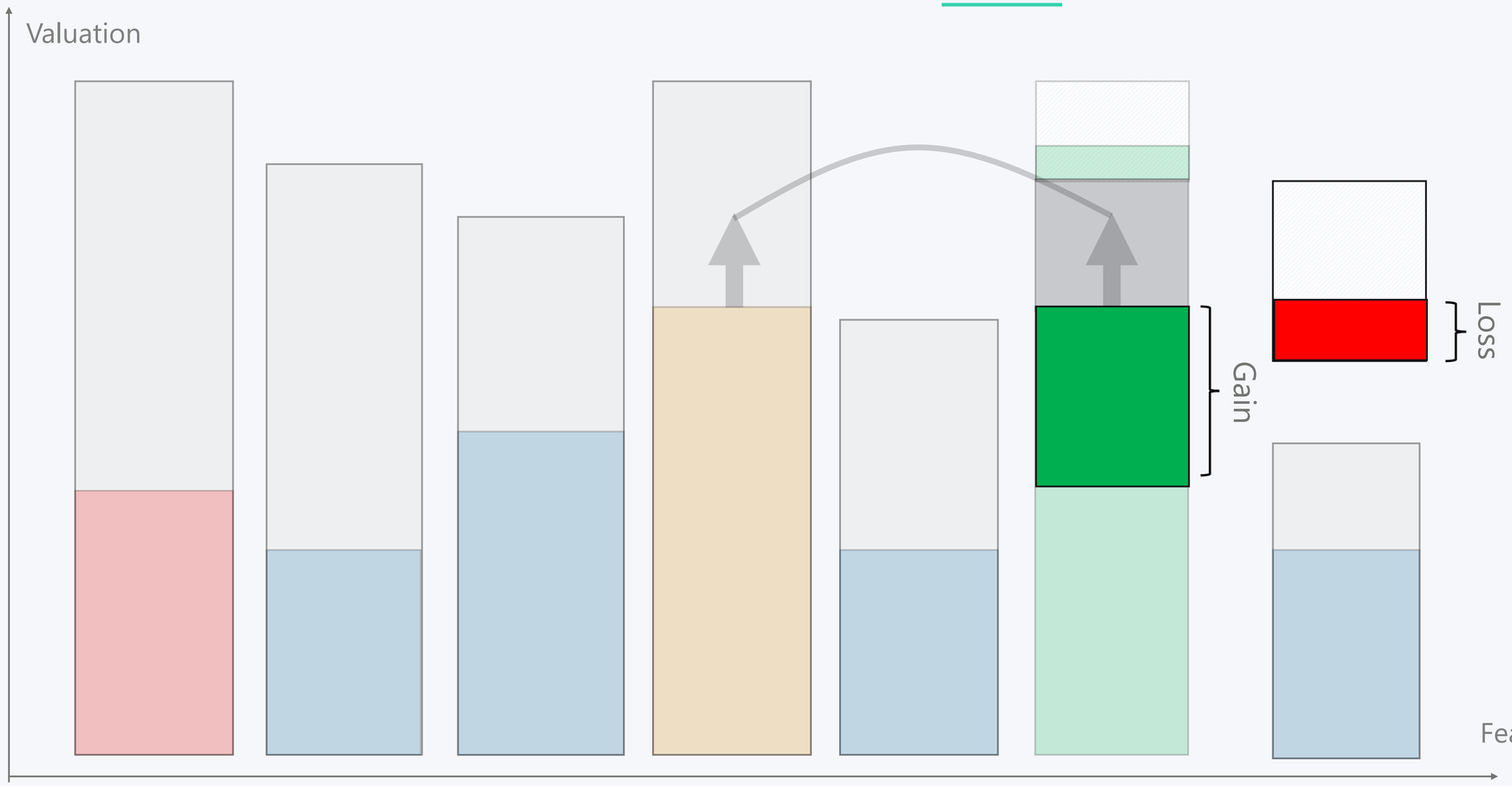


Strategy - INPUT_MAX

Increase price of Input Bid

Legend:
- Price of my BID
- Price of my INPUT BID
- Price of BIDs (others)
- Price of INPUT BIDs (others)
- Gain
- Loss

Perspective of Conspiring Bidder



Strategy - INPUT_MAX

Increase price of Input Bid

(+) Gain from overbidding on Input Bid

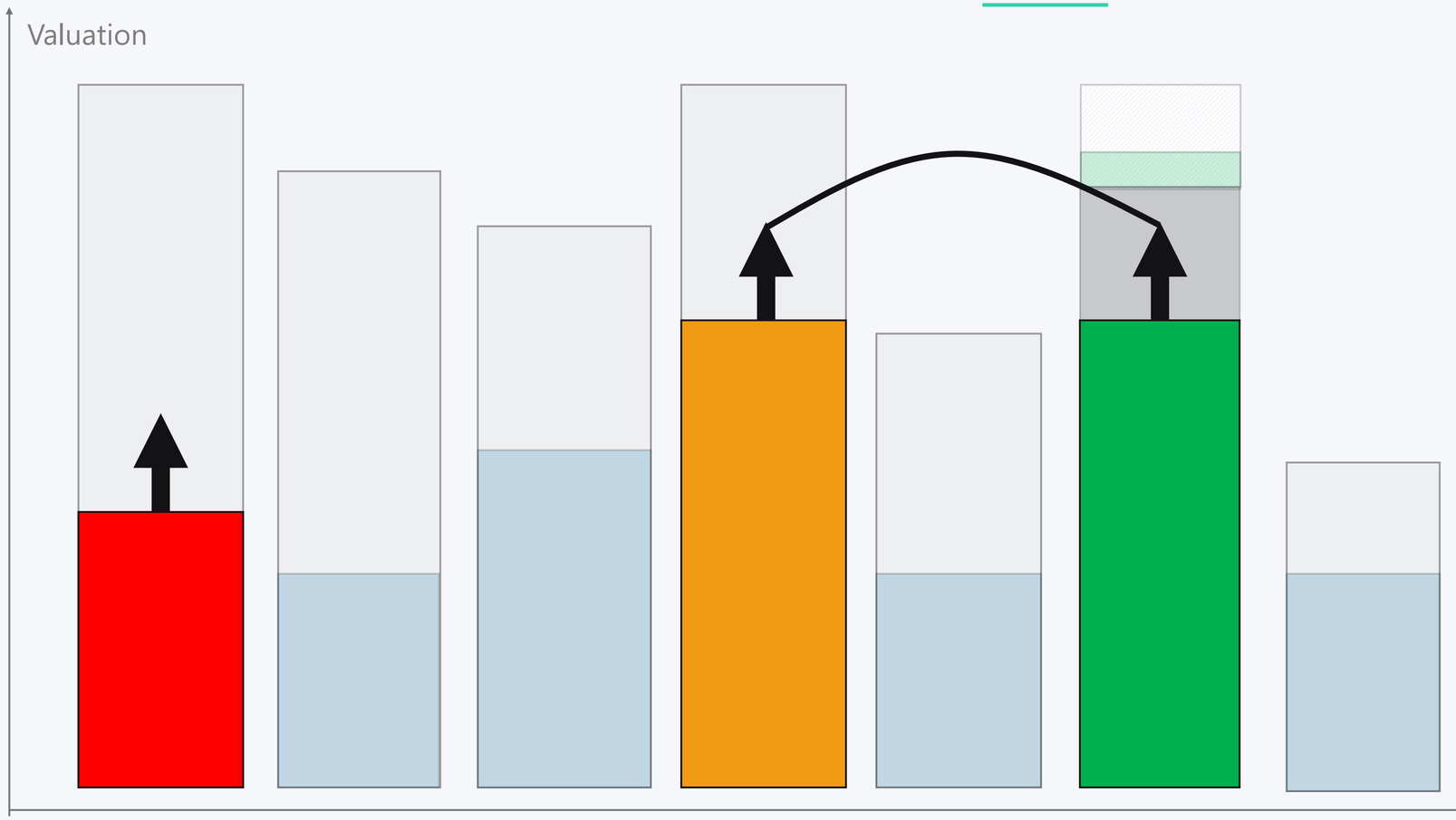
(-) Loss from decreasing Collaboration Gain

Gain > Loss

→ **Increase of Profit**

Legend: Price of my BID; Price of my INPUT BID; Price of BIDs (others); Price of INPUT BIDs (others); Gain; Loss

Perspective of Conspiring Bidder



Strategy - INPUT_MAX

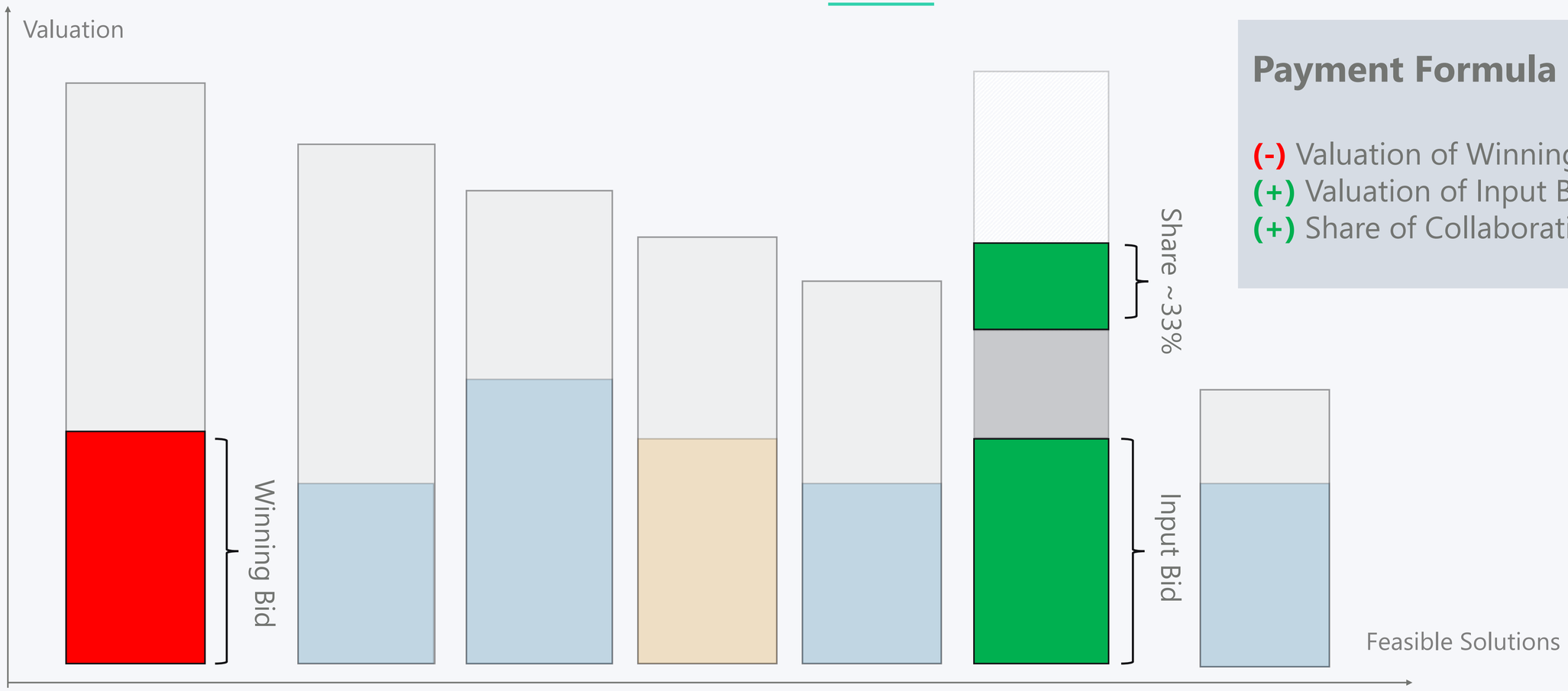
Increase price of Input Bid

Critical point
Increasing the Winning Bid price is **necessary** to maintain the Winning Bid Solution

→ **Can't increase** the Input But price **anymore** without simultaneously increasing Winning Bid price

Legend: Price of my BID | Price of my INPUT BID | Price of BIDs (others) | Price of INPUT BIDs (others) | Gain | Loss

Perspective of Conspiring Bidder

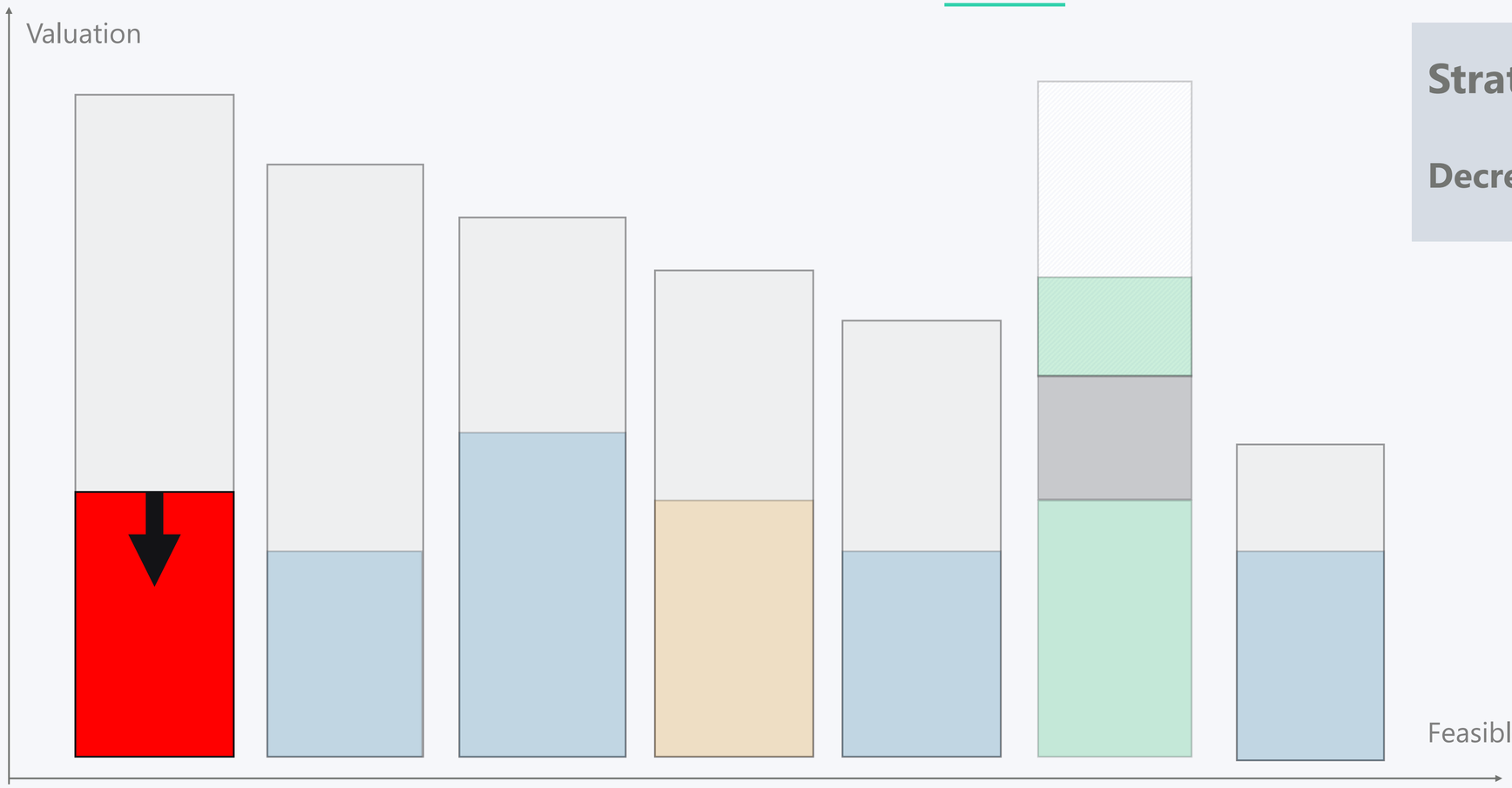


Payment Formula

(-) Valuation of Winning Bid
(+) Valuation of Input Bid
(+) Share of Collaboration Gain

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

Perspective of Conspiring Bidder

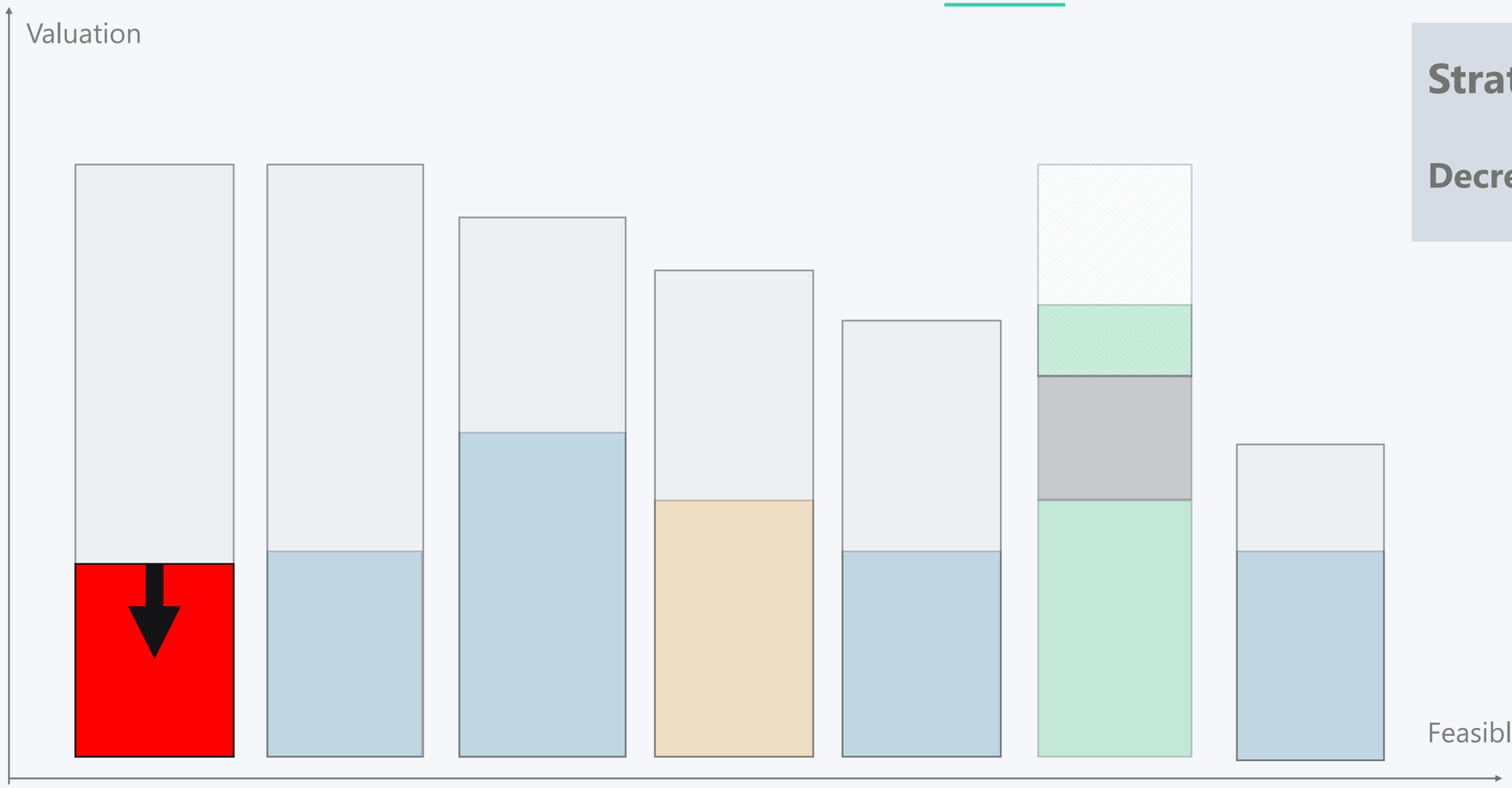


Strategy – WIN_LOW

Decrease valuation of Winning Bid

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

Perspective of Conspiring Bidder

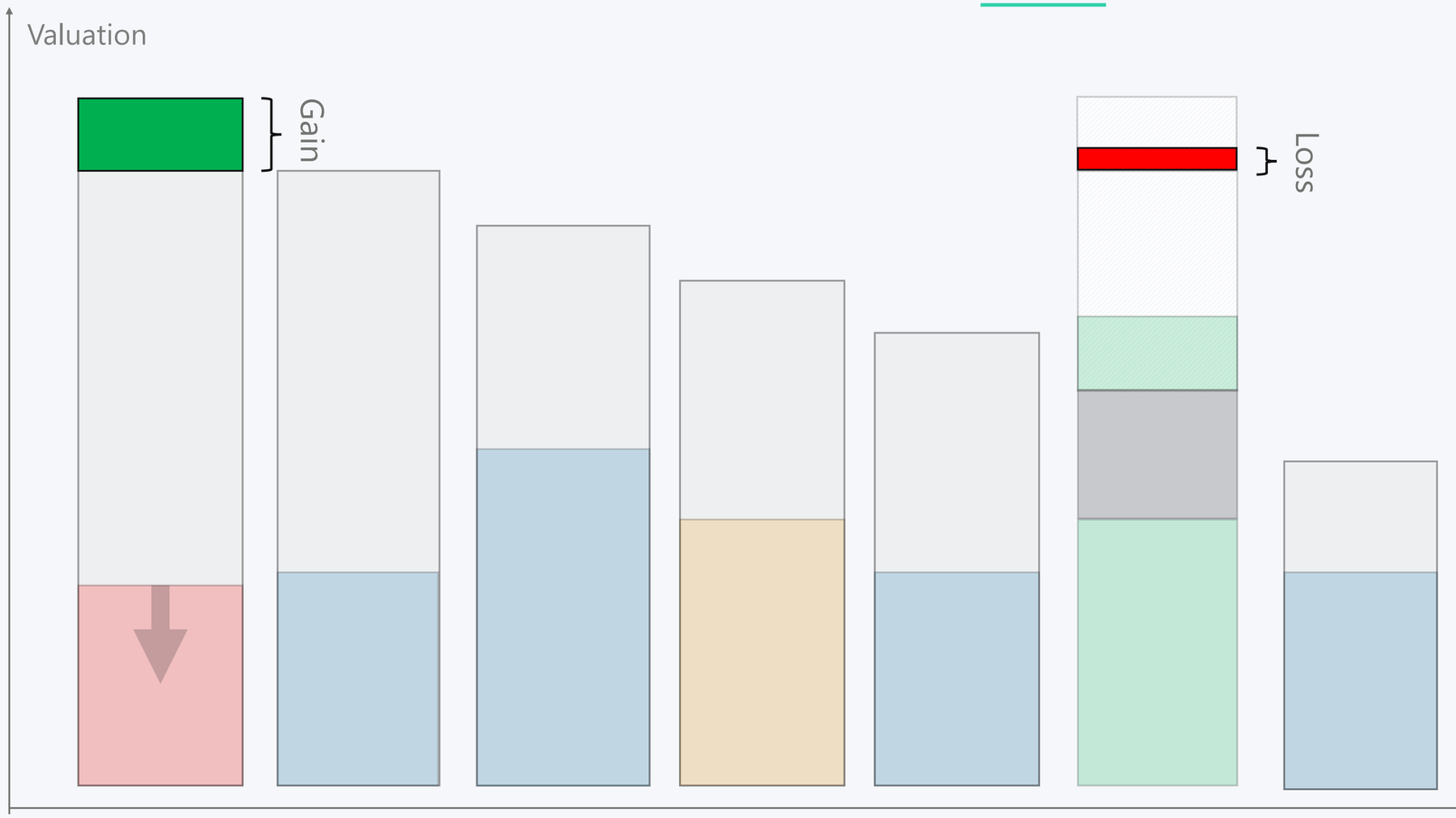


Strategy – WIN_LOW

Decrease valuation of Winning Bid

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

Perspective of Conspiring Bidder



Strategy – WIN_LOW

Decrease valuation of Winning Bid

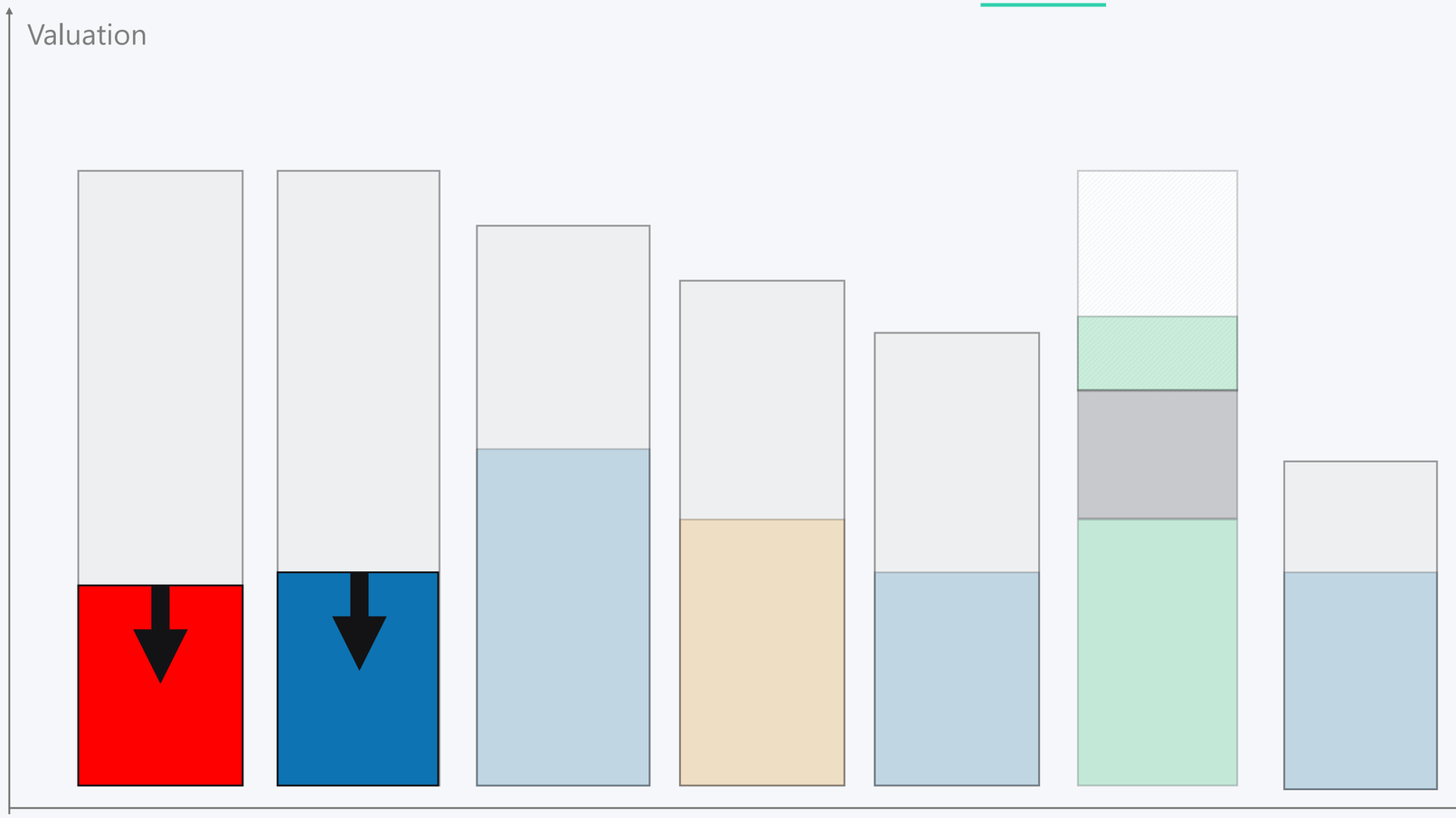
(+) Gain from Underbidding
(-) Loss from decreasing Collaboration Gain

Gain > Loss

→ **Increase of Profit**

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

Perspective of Conspiring Bidder



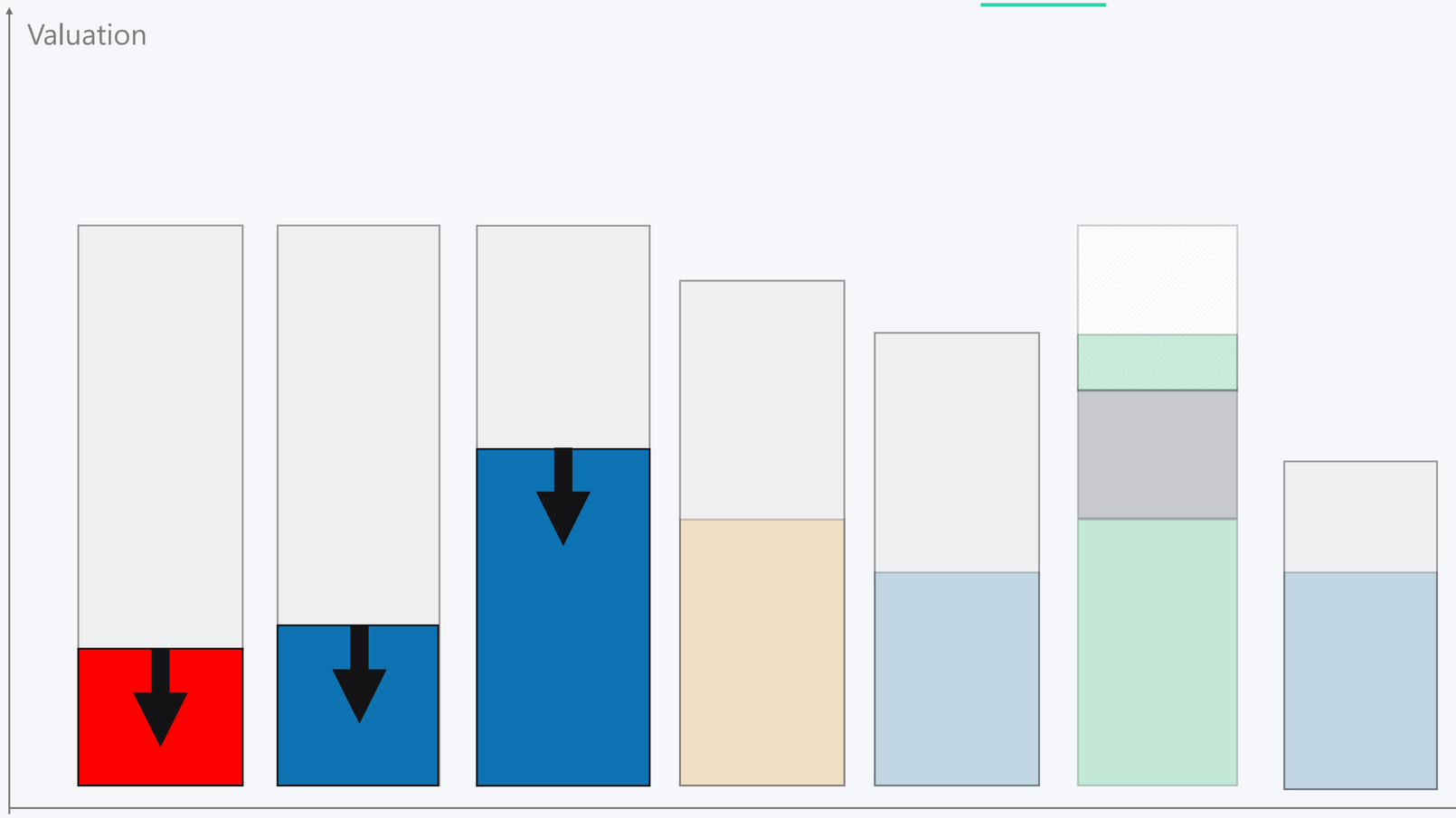
Strategy – WIN_LOW

Decrease valuation of Winning Bid

Critical point
Decreasing another Bid Valuation is necessary to maintain the same Winning Candidate

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

Perspective of Conspiring Bidder



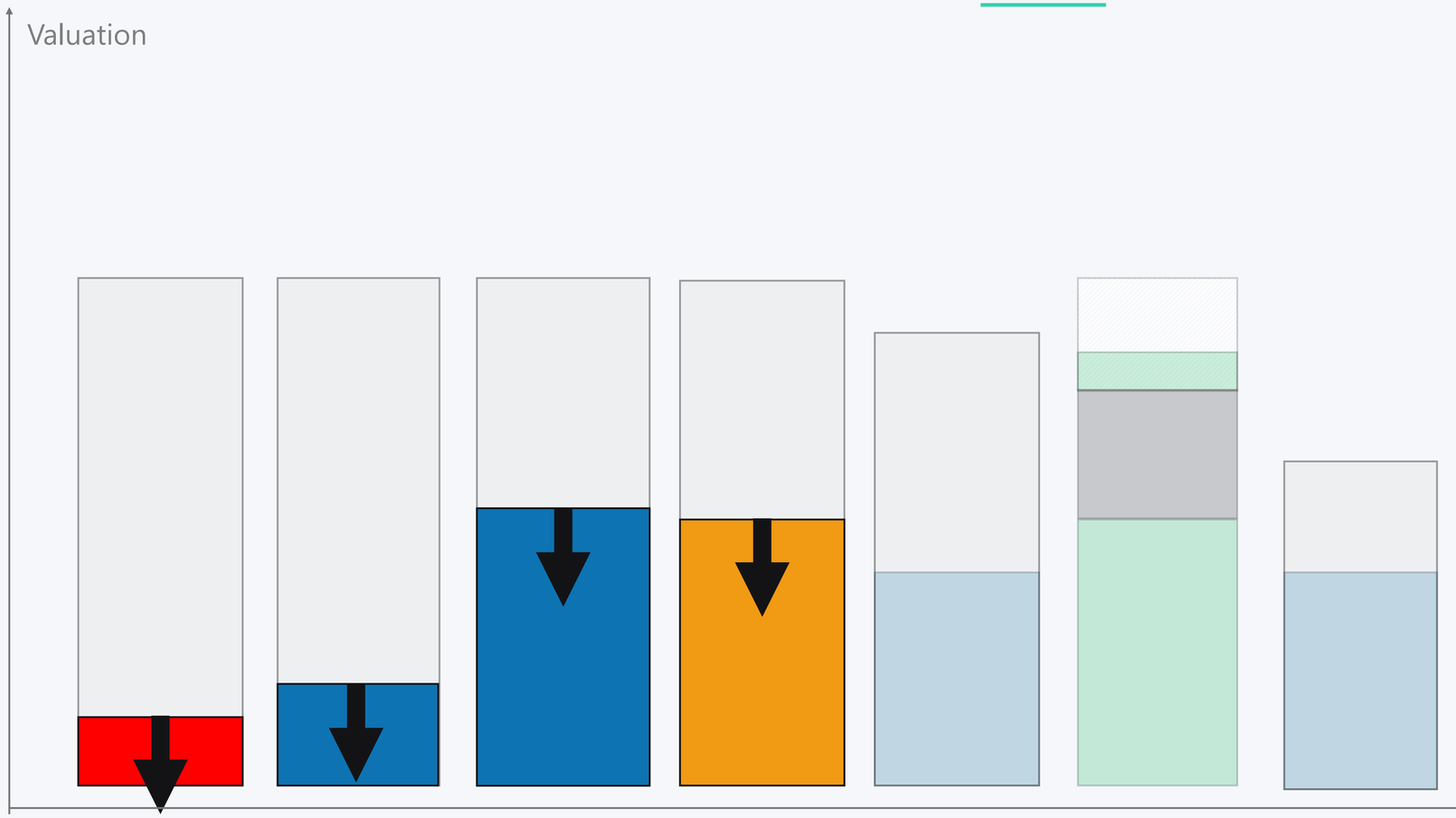
Strategy – WIN_LOW

Decrease valuation of Winning Bid

Critical point
Decreasing another Bid Valuation is necessary to maintain the same Winning Candidate

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

Perspective of Conspiring Bidder



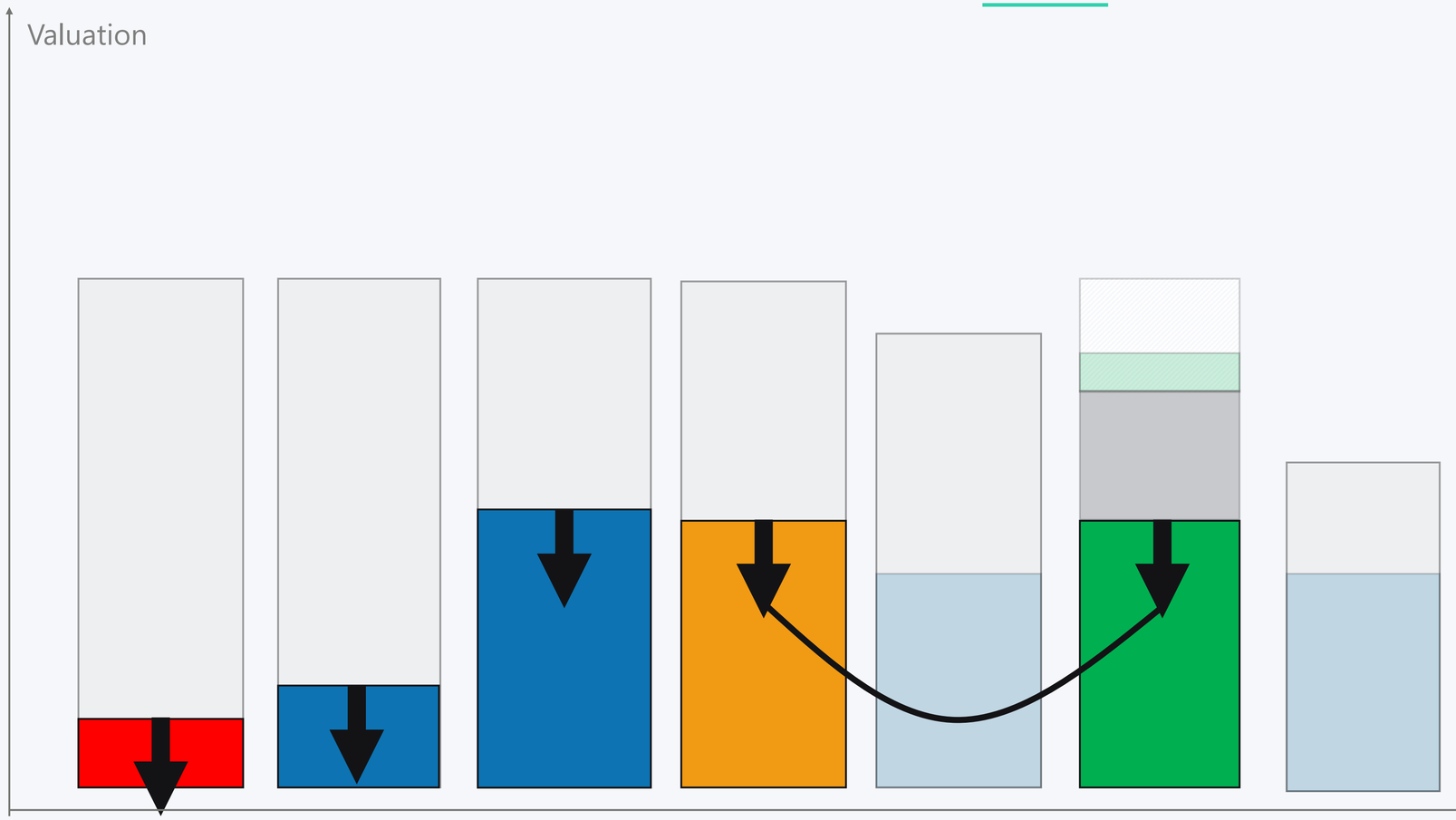
Strategy – WIN_LOW

Decrease valuation of Winning Bid

Critical point
Decreasing another Bid Valuation is necessary to maintain the same Winning Candidate

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

Perspective of Conspiring Bidder



Strategy – WIN_LOW

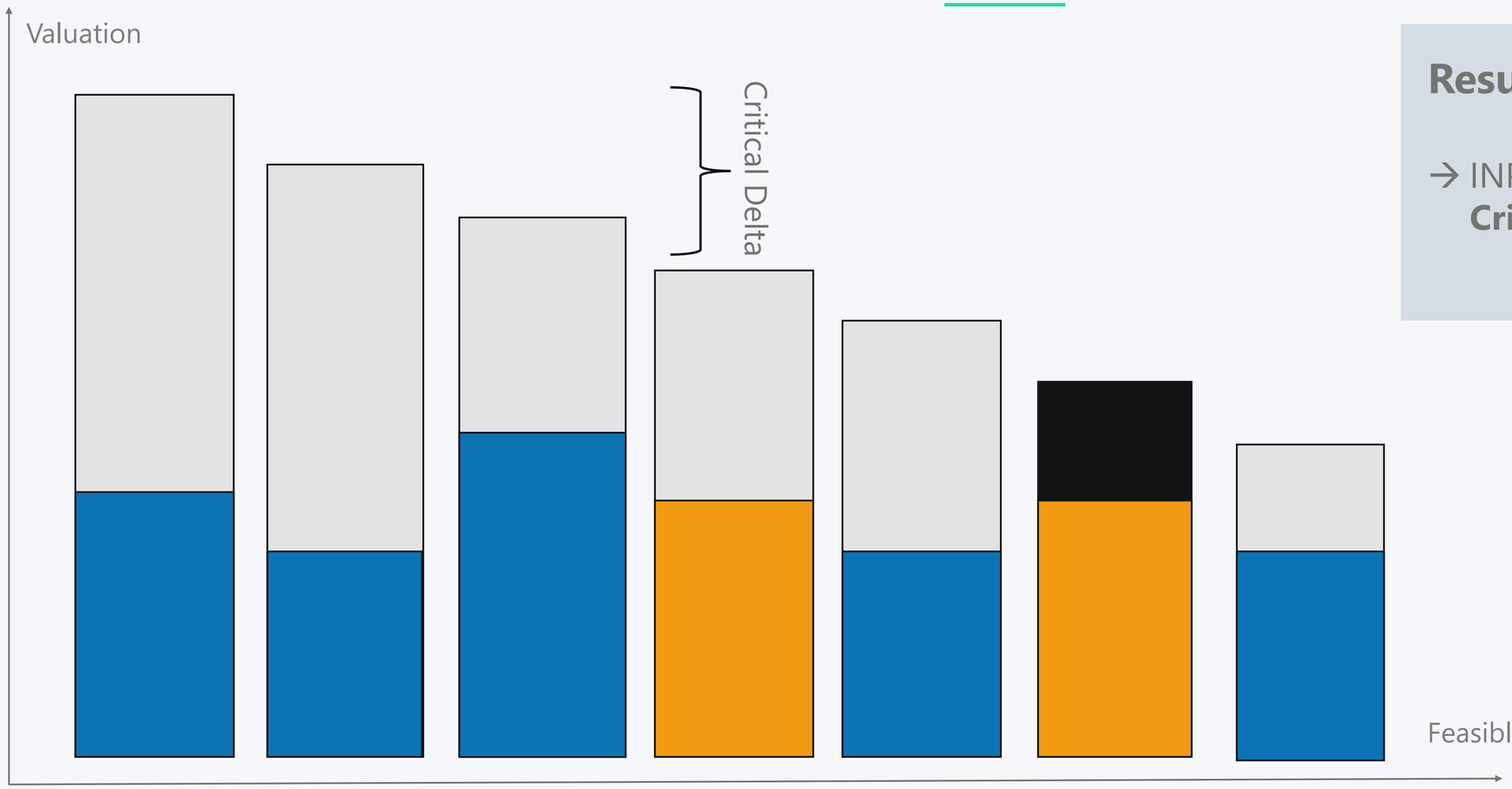
Decrease valuation of Winning Bid

Critical point
Decreasing the Input Bid Valuation is necessary to maintain the Winning Candidate

→ **Can't decrease** bid valuations **anymore** without simultaneously decreasing guaranteed profit

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

Perspective of Conspiring Bidder



Result

→ INPUT_MAX and WIN_LOW exploit the **Critical Delta**

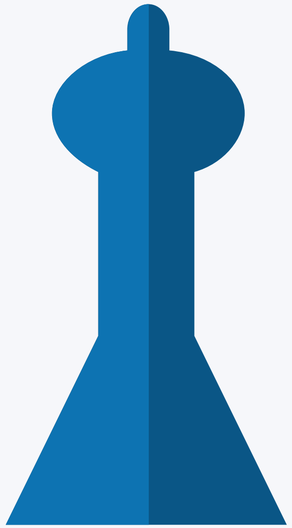
Legend: Price of my BID | Price of my INPUT BID | Price of BIDs (others) | Price of INPUT BIDs (others)

Strategies

Conspiring Bidder Strategies

INPUT_MAX
Increase price of Input Bid

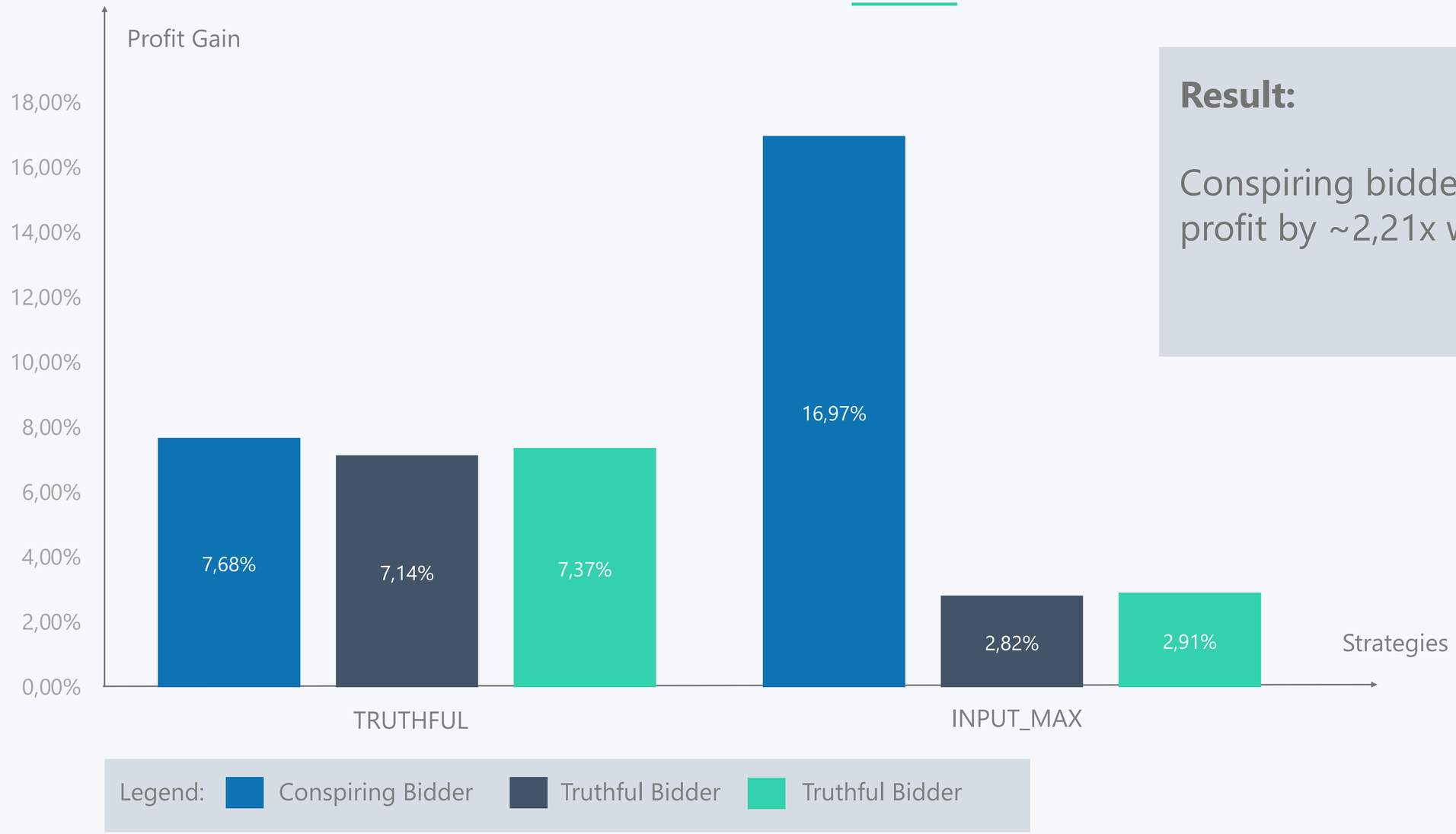
WIN_LOW
Decrease price of Winning Bid



Strategic Bidder Strategies

INPUT_MANIPULATION
Overbid/Underbid on the Input Bid

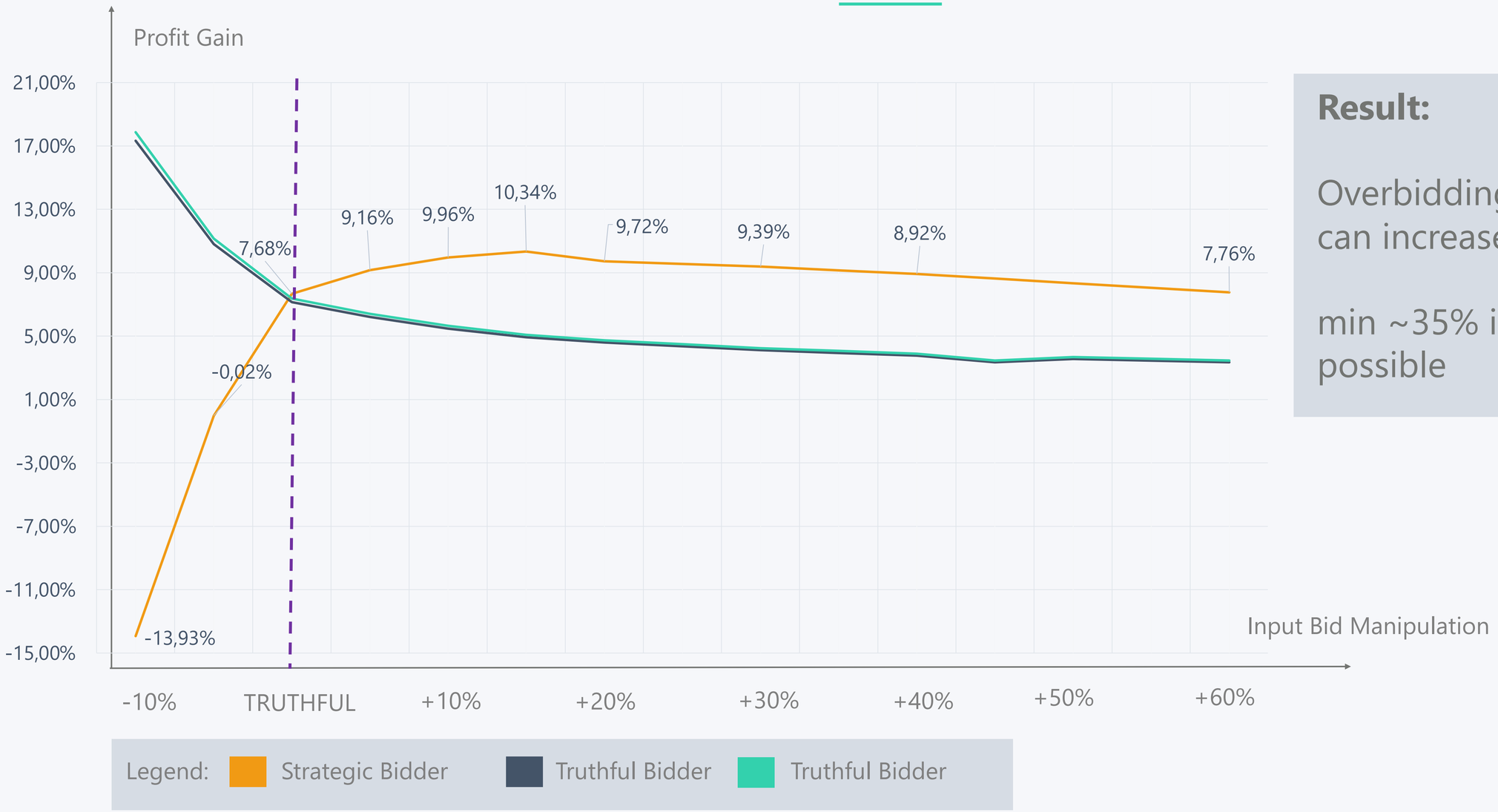
Test Results for Conspiring Bidder



Result:

Conspiring bidder can increase her profit by ~2,21x with INPUT_MAX

Test Results for Strategic Bidder



Result:

Overbidding on the Input Bid can increase profit

min ~35% increase of profit possible

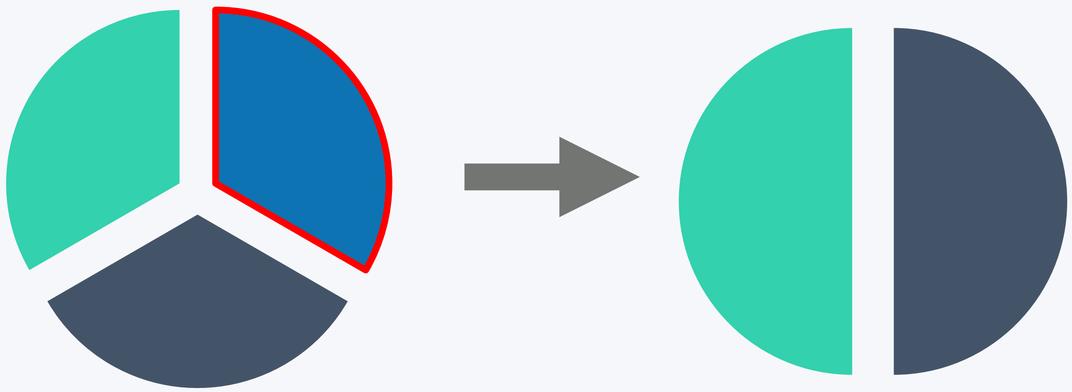
4.2 Bidding Strategies for Modified Egalitarian Profit Sharing

Modified Egalitarian Profit Sharing

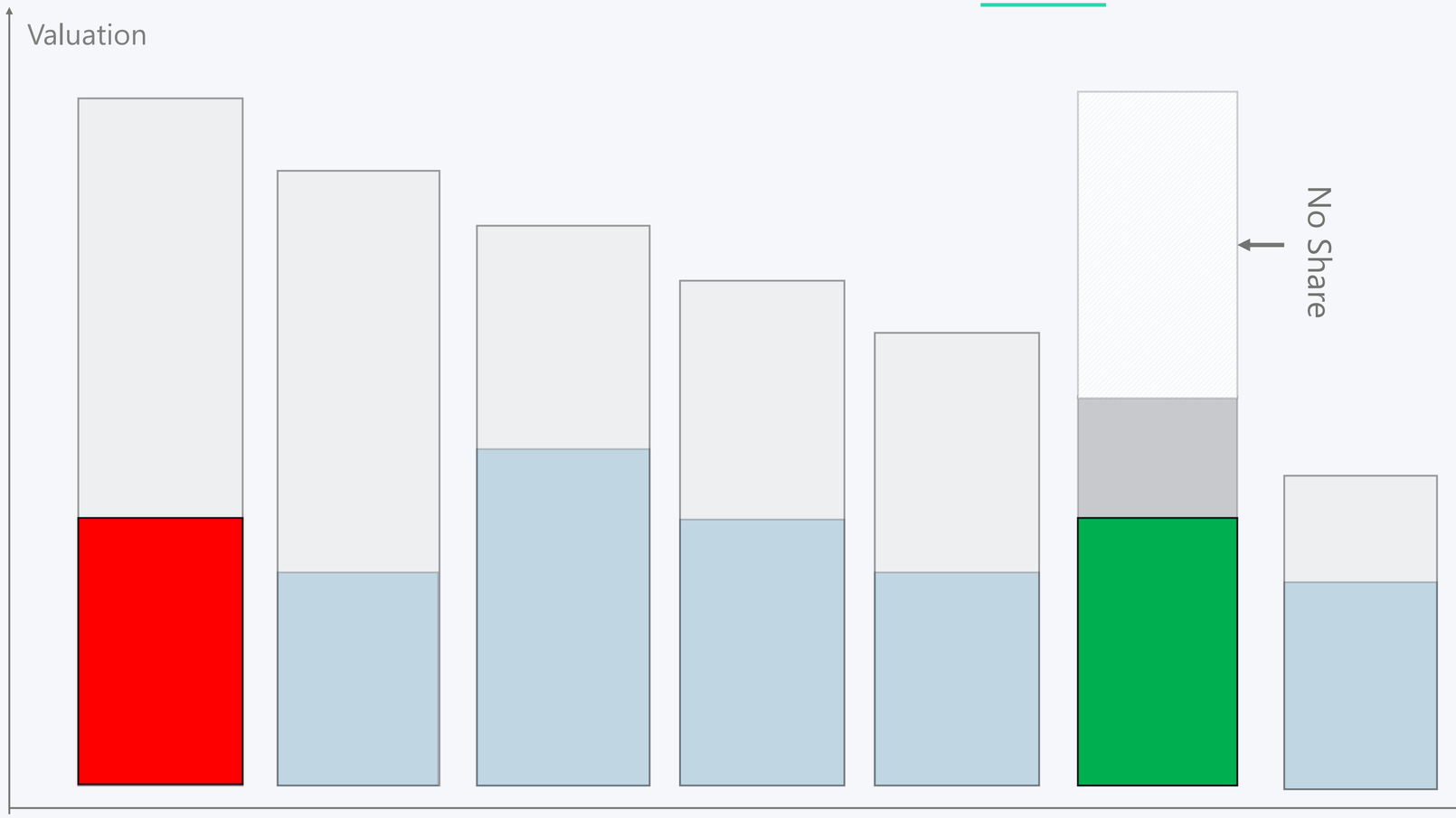
Profit Sharing Rule:

Share the collaboration gain equally between the carriers

Modification:
If a carrier wins her own Input Bid then she is excluded from the profit sharing



Perspective of Conspiring Bidder



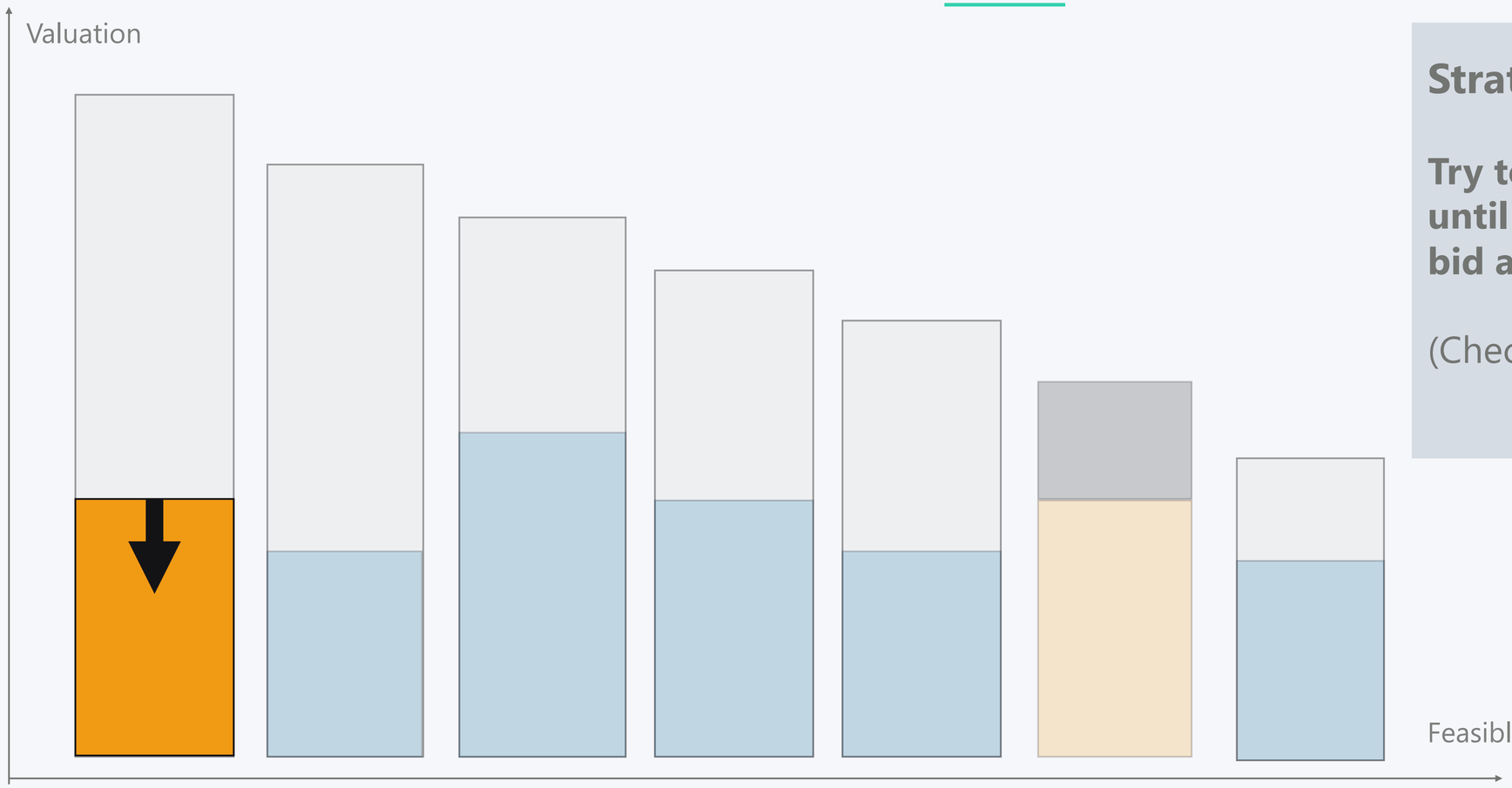
Payment Formula

In general
Share = 1/(number of carriers)

Exception
If you get back your own input bit → No Share

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

Perspective of Conspiring Bidder



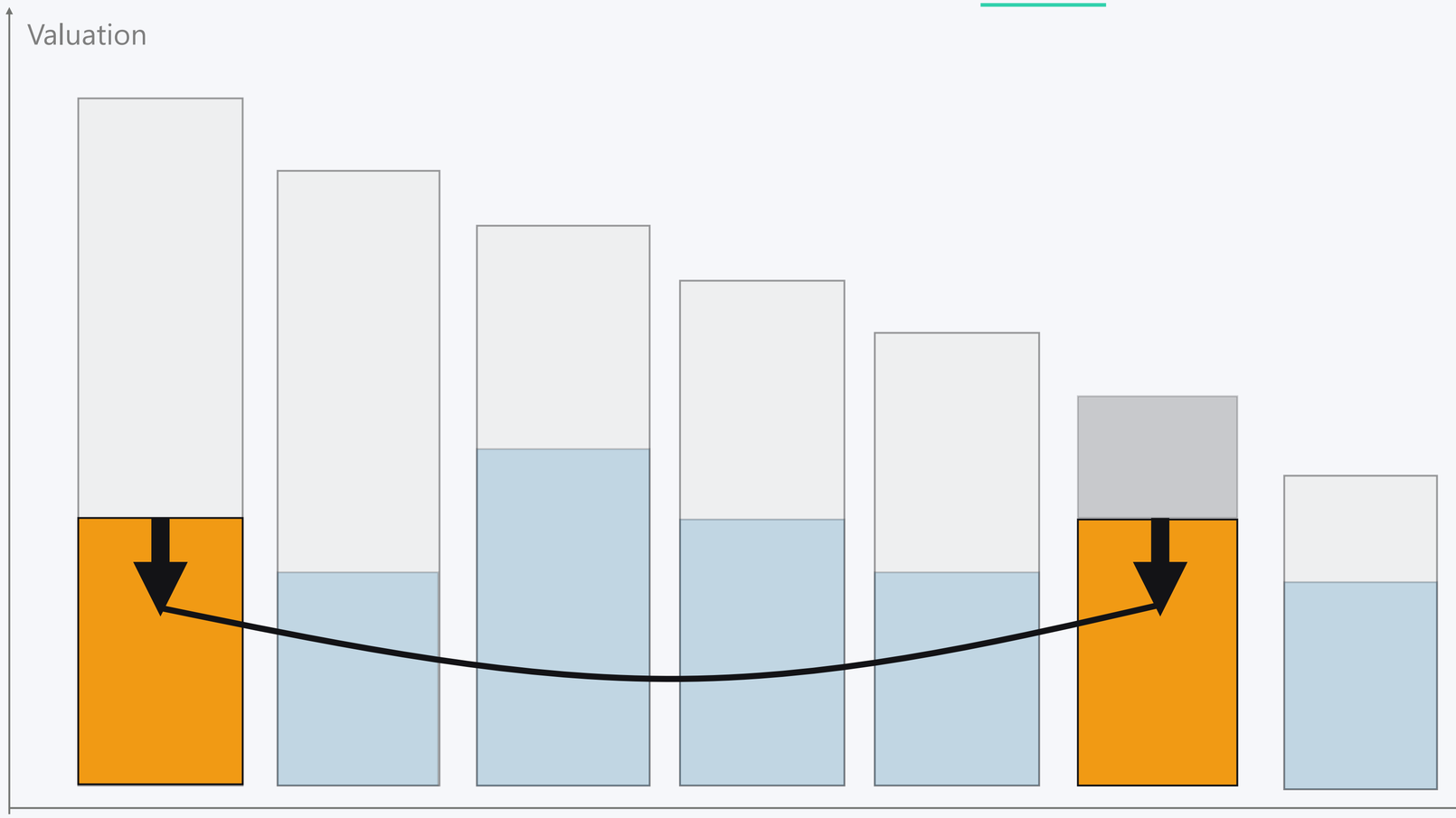
Strategy – INPUT_ENTER

Try to decrease your input valuation until you won't win your own input bid anymore

(Check profitability afterwards)

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

Perspective of Conspiring Bidder



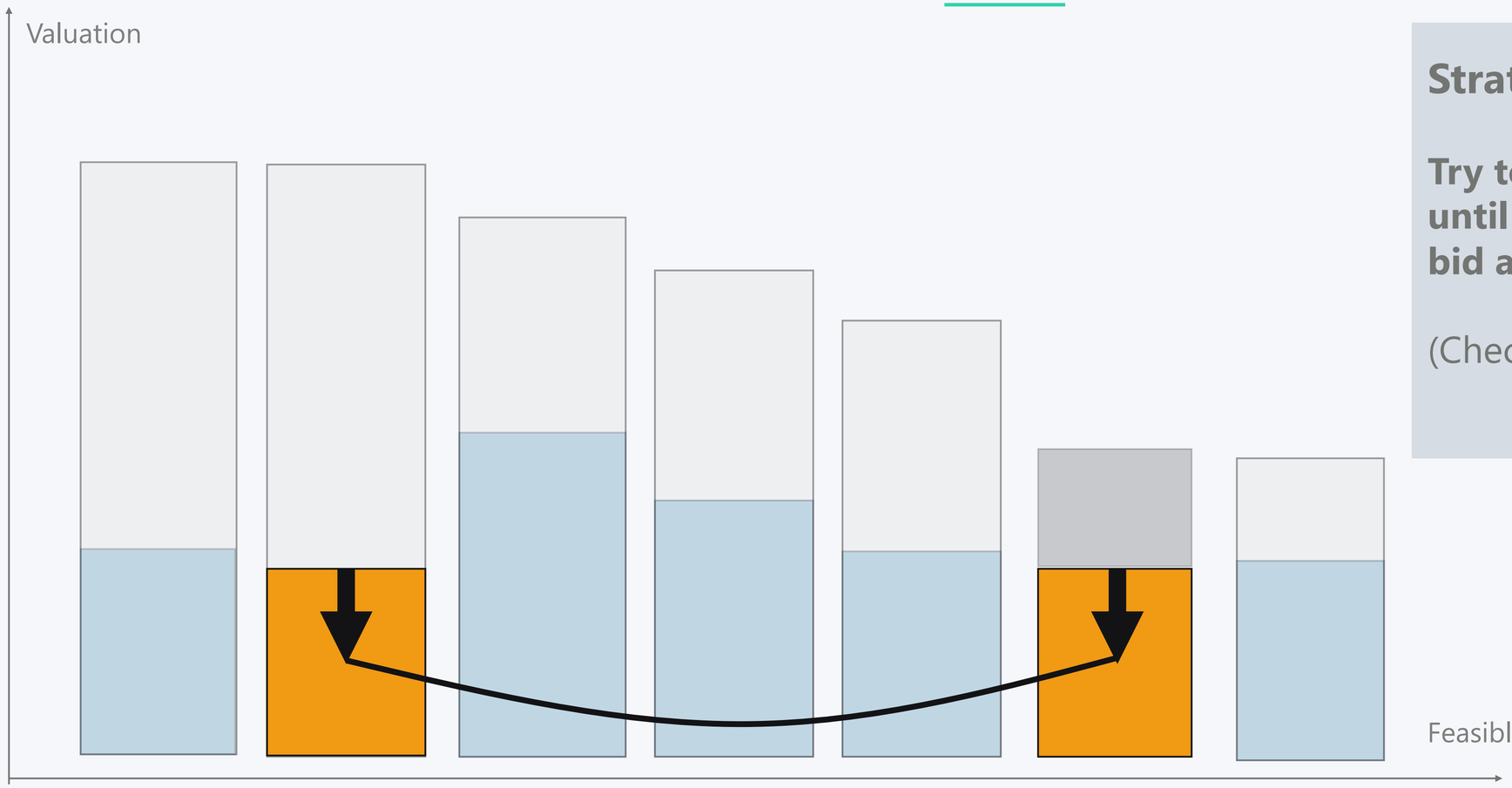
Strategy – INPUT_ENTER

Try to decrease your input valuation until you won't win your own input bid anymore

Observation
Decreasing your input bid impacts multiple candidates

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

Perspective of Conspiring Bidder



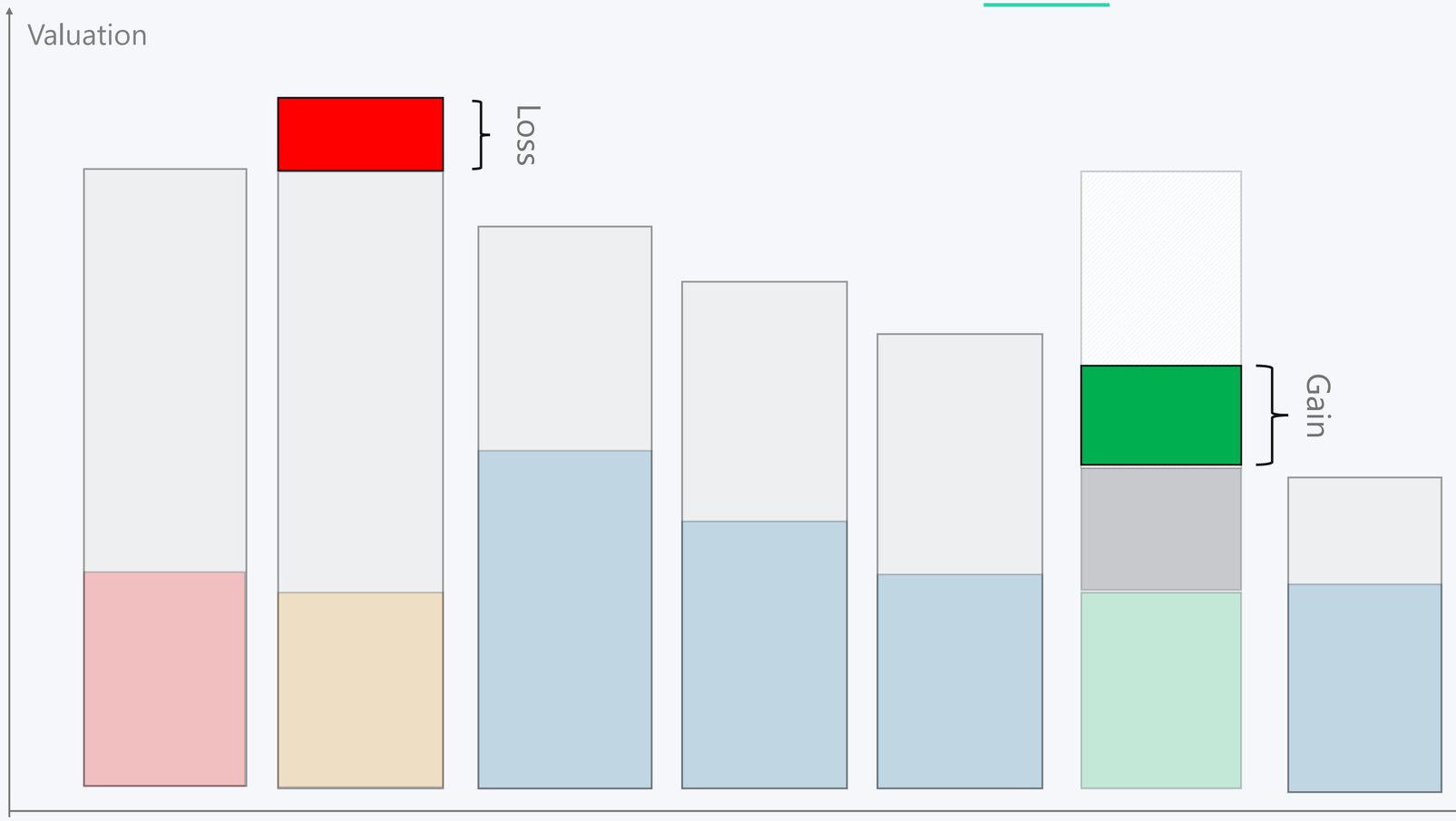
Strategy – INPUT_ENTER

Try to decrease your input valuation until you won't win your own input bid anymore

(Check profitability afterwards)

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

Perspective of Conspiring Bidder



Strategy – INPUT_ENTER

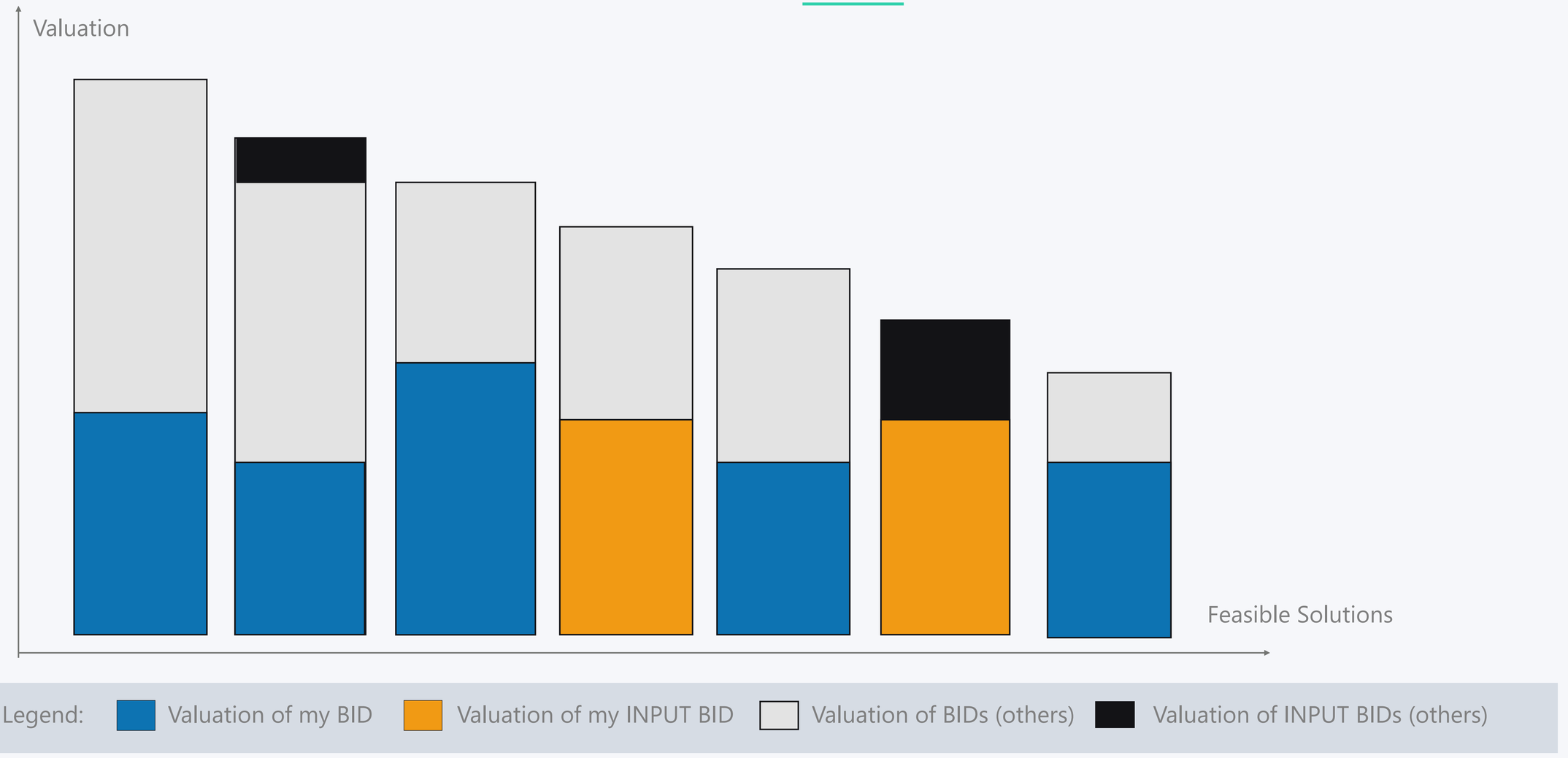
Try to decrease your input valuation until you won't win your own input bid anymore

(+) Gain from getting part of the collaboration share
(-) Loss from decreasing guaranteed profit of input bid

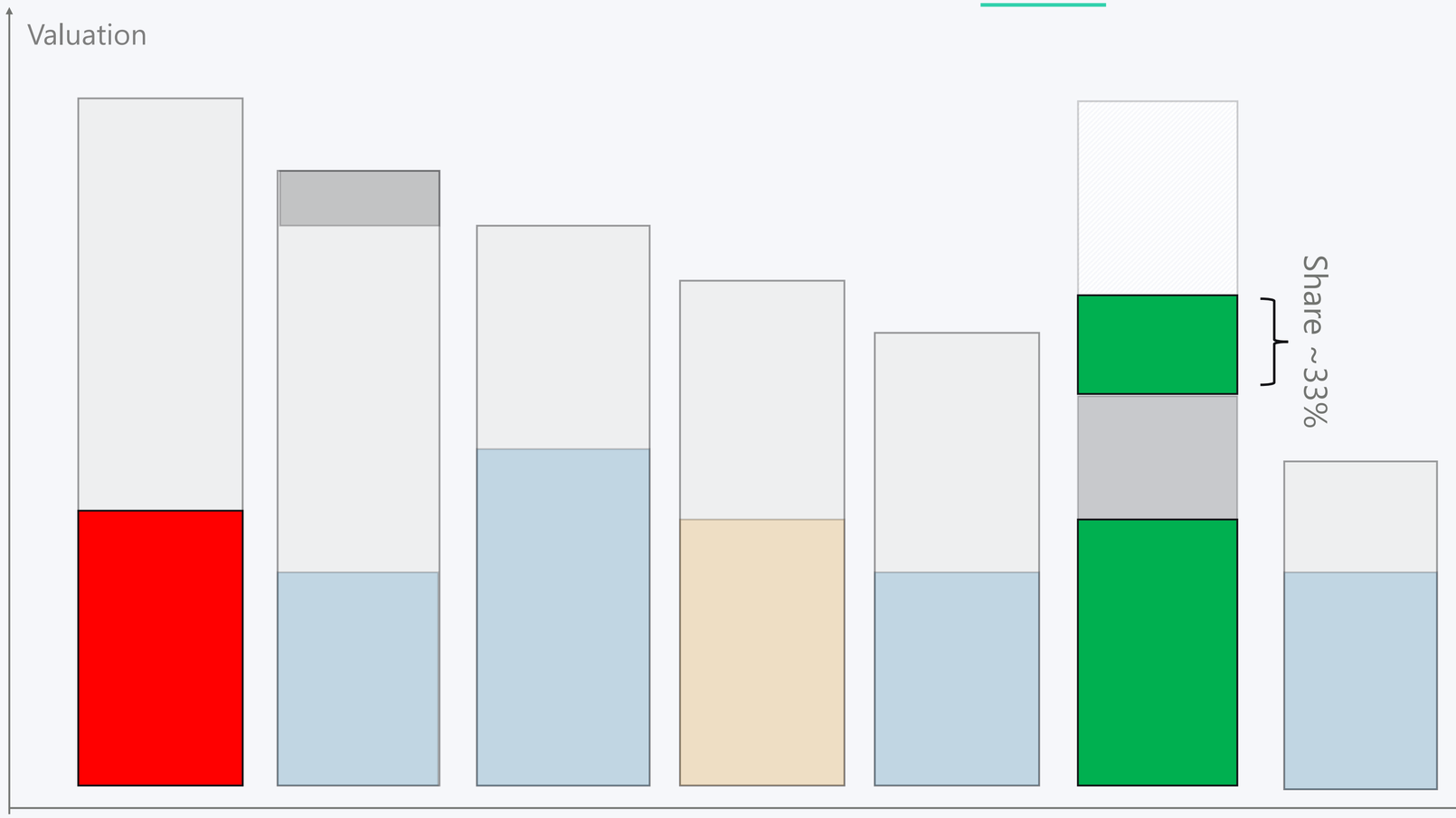
→ Profitability check necessary

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

Perspective of Conspiring Bidder



Perspective of Conspiring Bidder



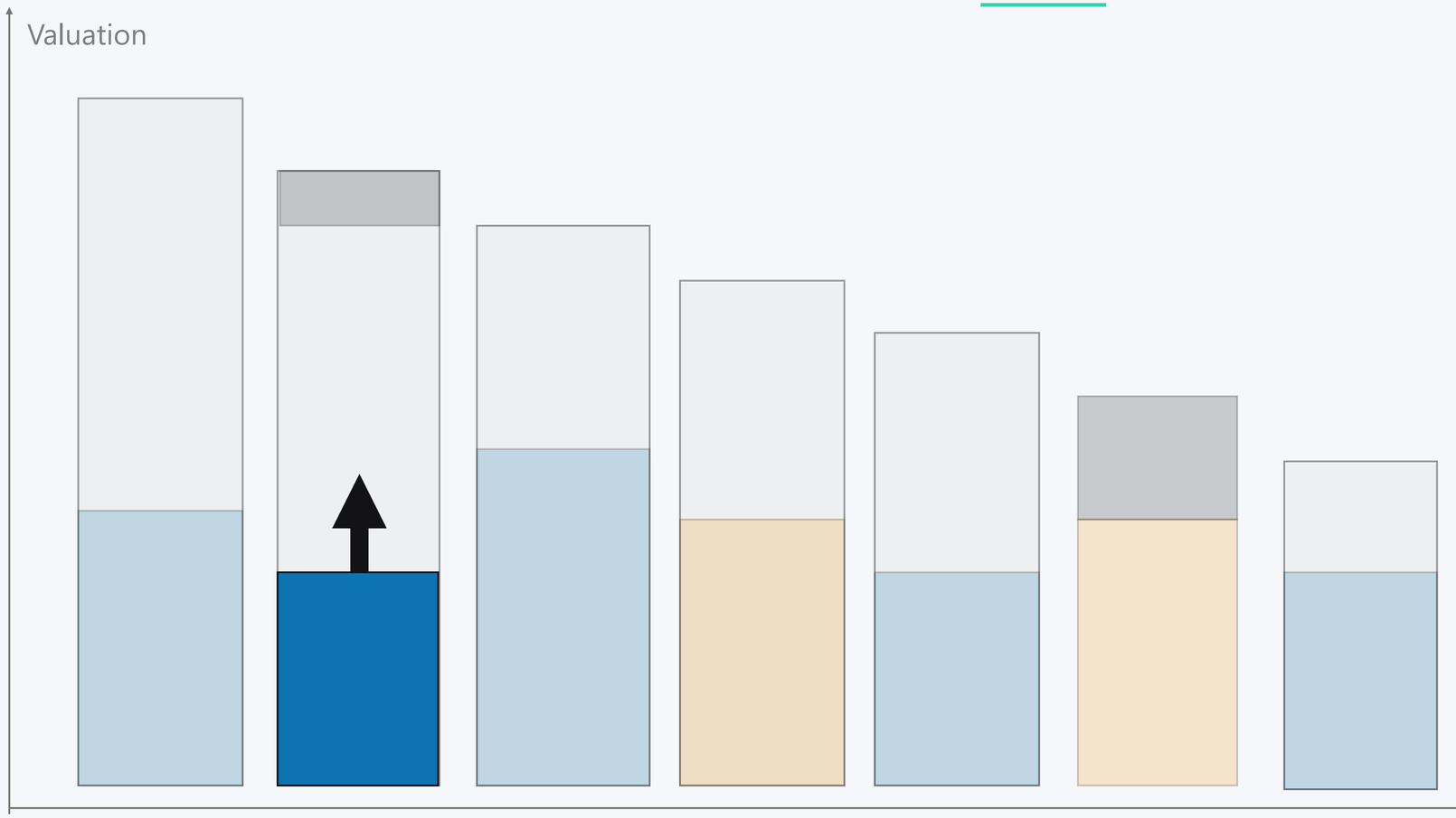
Payment Formula

In general
Share = 1/(number of carriers)

Exception
If you get back your own Input Bid → No Share

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

Perspective of Conspiring Bidder



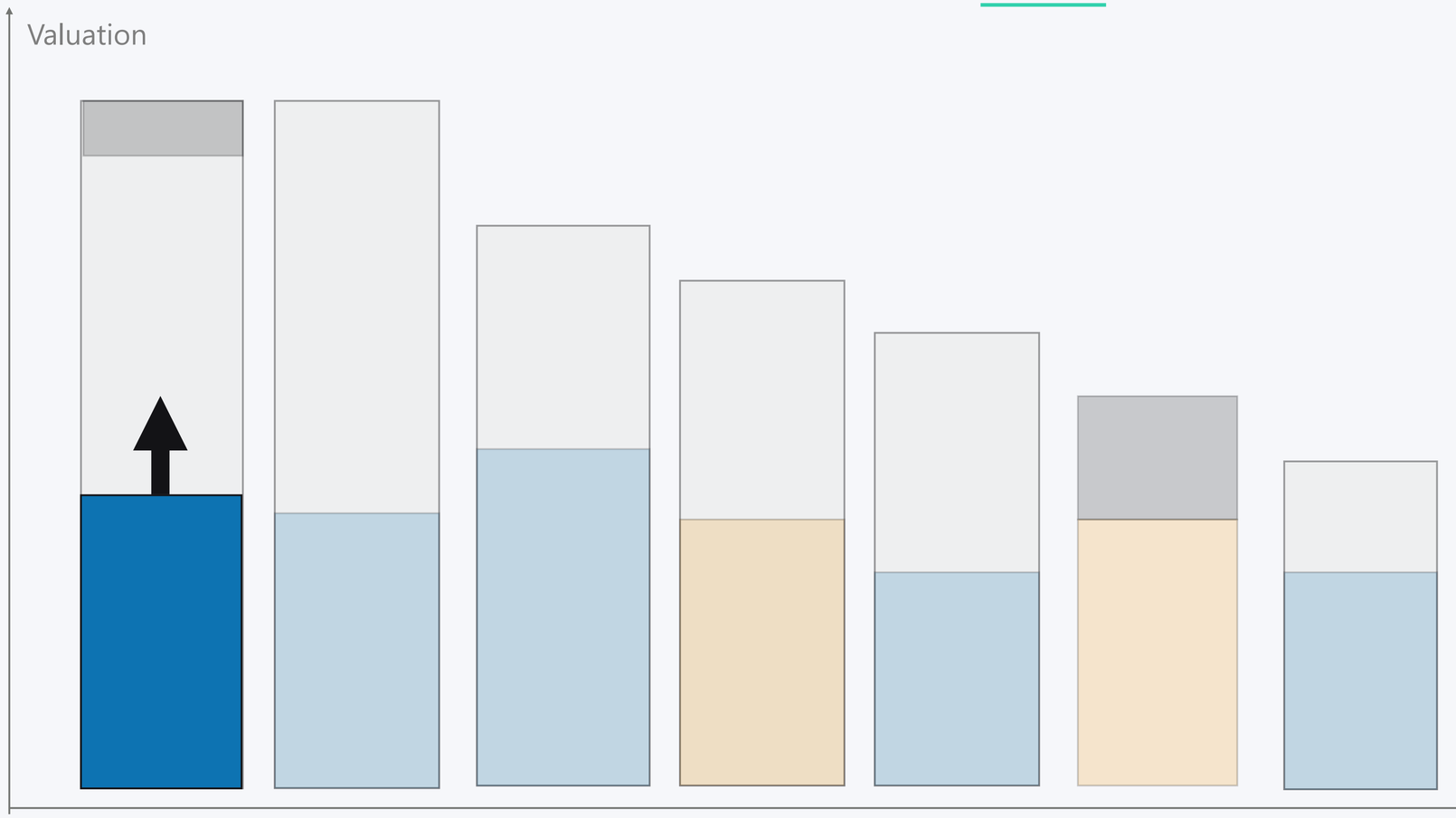
Strategy – BID_KICKOUT

Try to increase your valuation of a bid in another candidate to force the mechanism to determine a winning candidate in which another/other carrier(s) will be excluded from the collaboration gain

(Check profitability afterwards)

Legend: Valuation of my BID | Valuation of my INPUT BID | Valuation of other BIDs | Valuation of other INPUT BIDs

Perspective of Conspiring Bidder



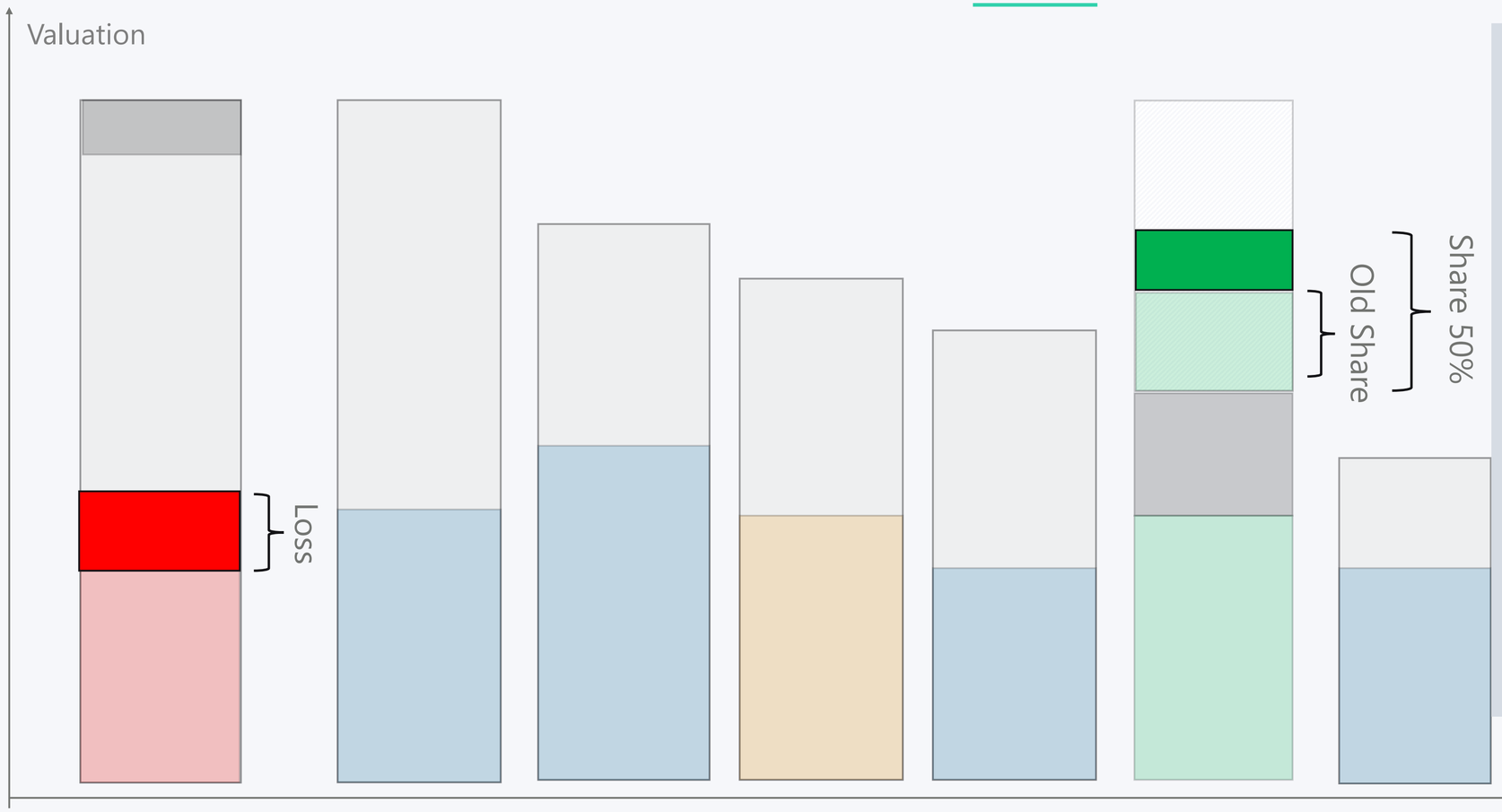
Strategy – BID_KICKOUT

Try to increase your valuation of a bid in another candidate to force the mechanism to determine a winning candidate in which another/other carrier(s) will be excluded from the collaboration gain

(Check profitability afterwards)

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

Perspective of Conspiring Bidder



Strategy – BID_KICKOUT

Try to increase your valuation of a bid in another candidate to force the mechanism to determine a winning candidate in which another/other carrier(s) will be excluded from the collaboration gain

(+) Gain from getting more of the collaboration share
(-) Loss from overbidding

→ Profitability Check necessary

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

Strategies

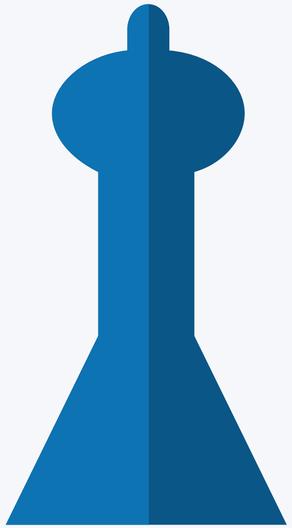
Conspiring Bidder Strategies

INPUT_MAX
Increase valuation of Input Bid

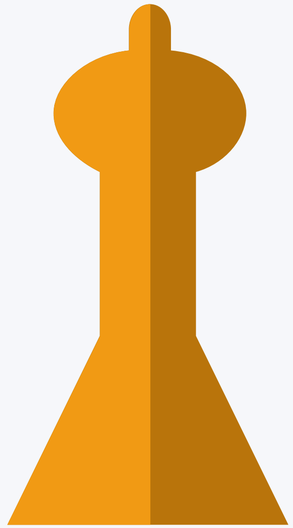
INPUT_ENTER
Try to decrease your input valuation until you won't win you own input bid anymore

BID_KICKOUT
Try to increase your valuation of a bid in another candidate to force the mechanism to determine a winning candidate in which another/other carrier(s) will be excluded from the collaboration gain

LOW_WIN
Decrease valuation of Winning Bid

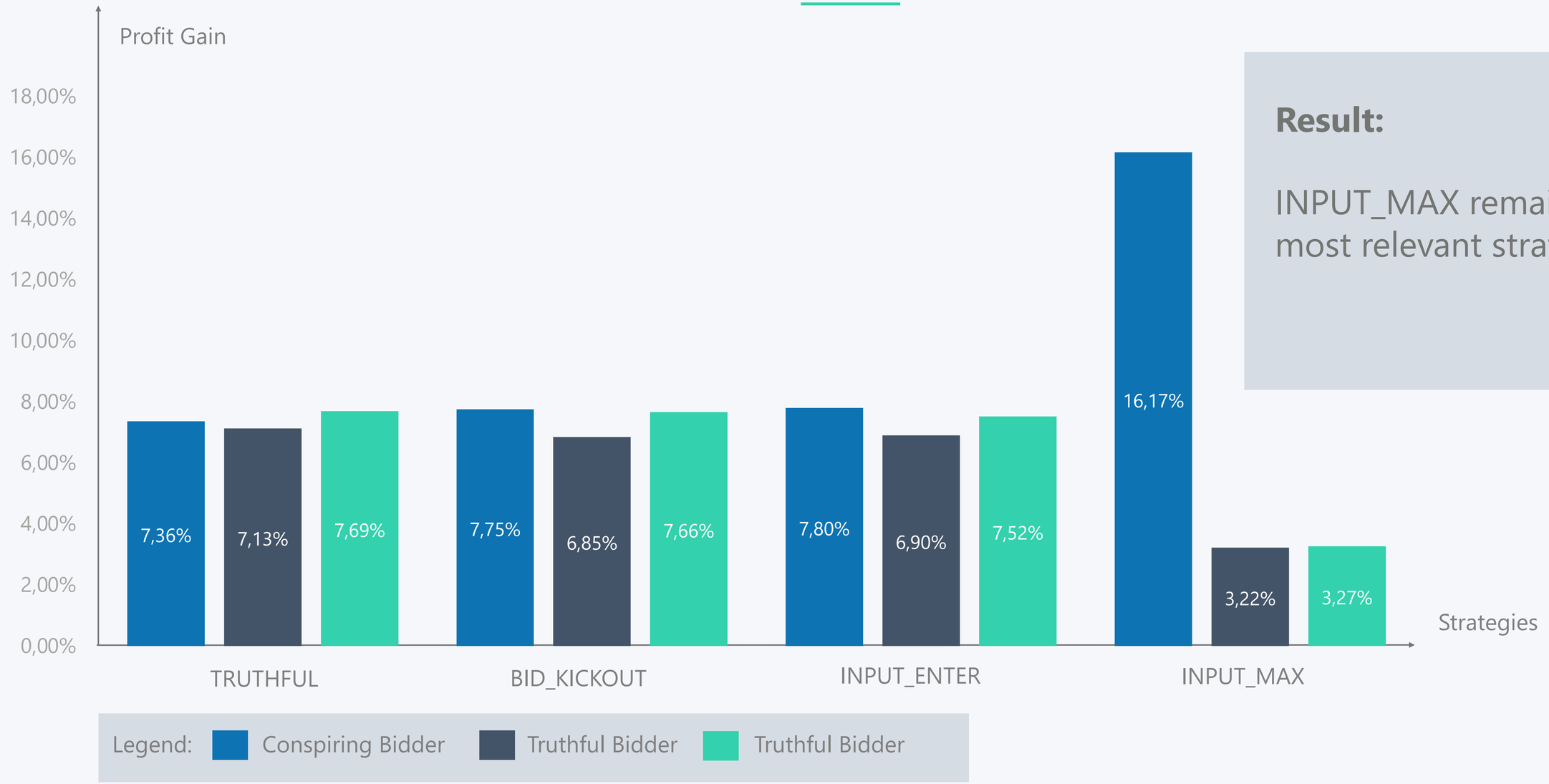


Strategic Bidder Strategies



INPUT_MANIPULATION
Overbid/Underbid on the Input Bid

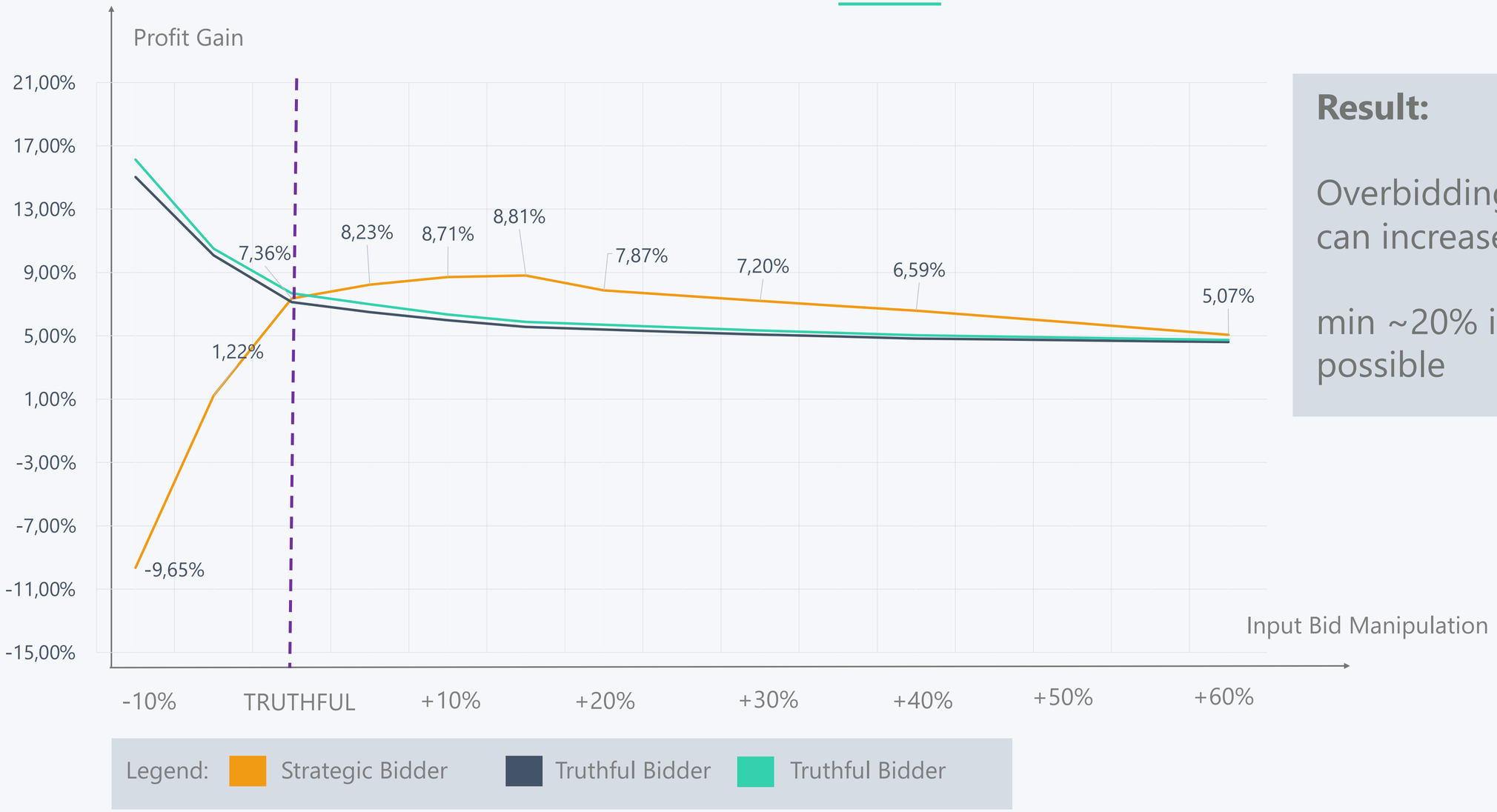
Simulation Results for Conspiring Bidder



Result:

INPUT_MAX remains the most relevant strategy

Simulation Results for Strategic Bidder

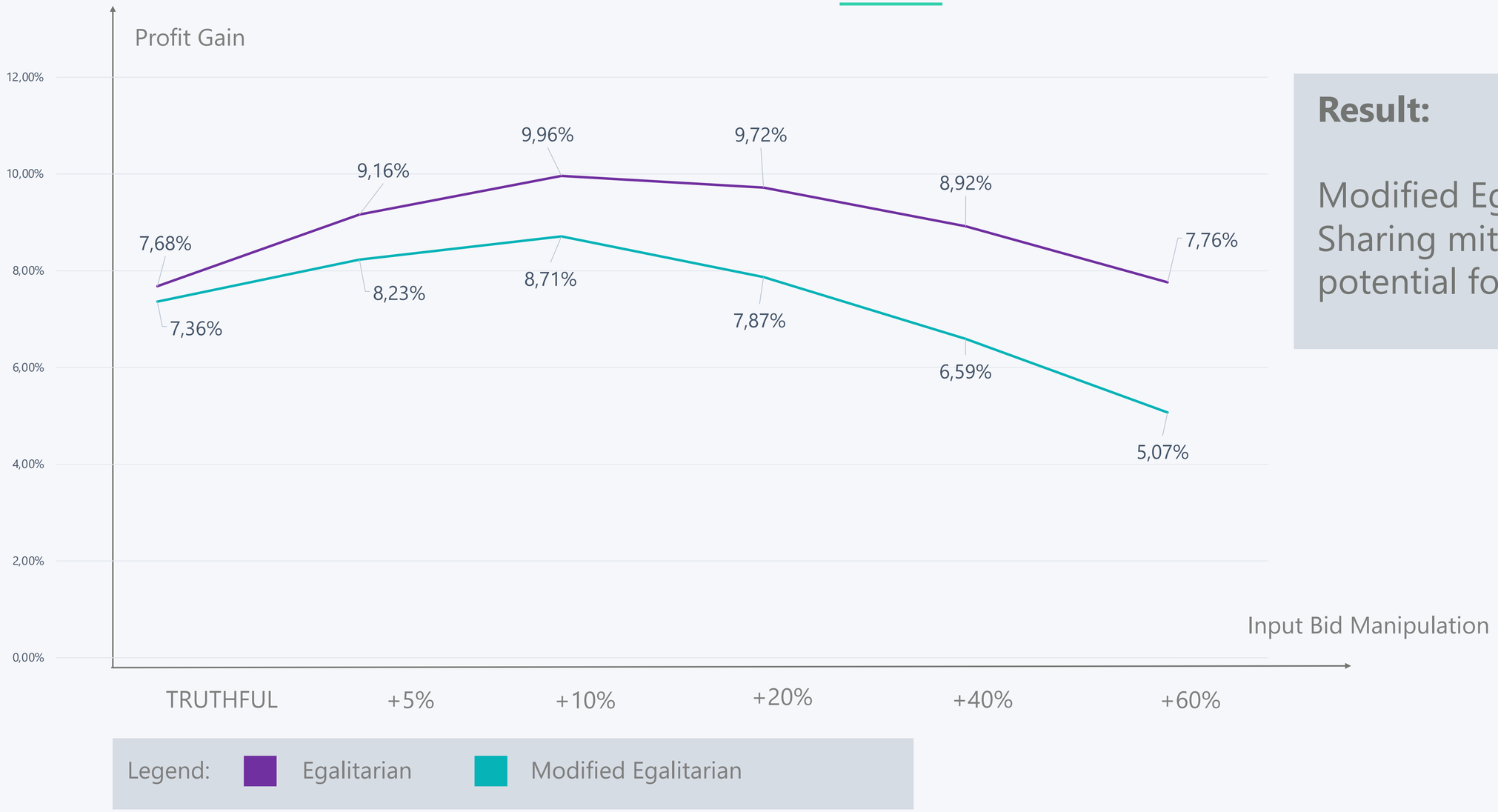


Result:

Overbidding on the Input Bid can increase profit

min ~20% increase of profit possible

Egalitarian vs. Modified Egalitarian Profit Sharing



Result:

Modified Egalitarian Profit Sharing mitigates the potential for overbidding

4.3 Bidding Strategies for Purchase/Sale Weight Profit Sharing

Purchase/Sale Weights Profit Sharing

Profit Sharing Rule:

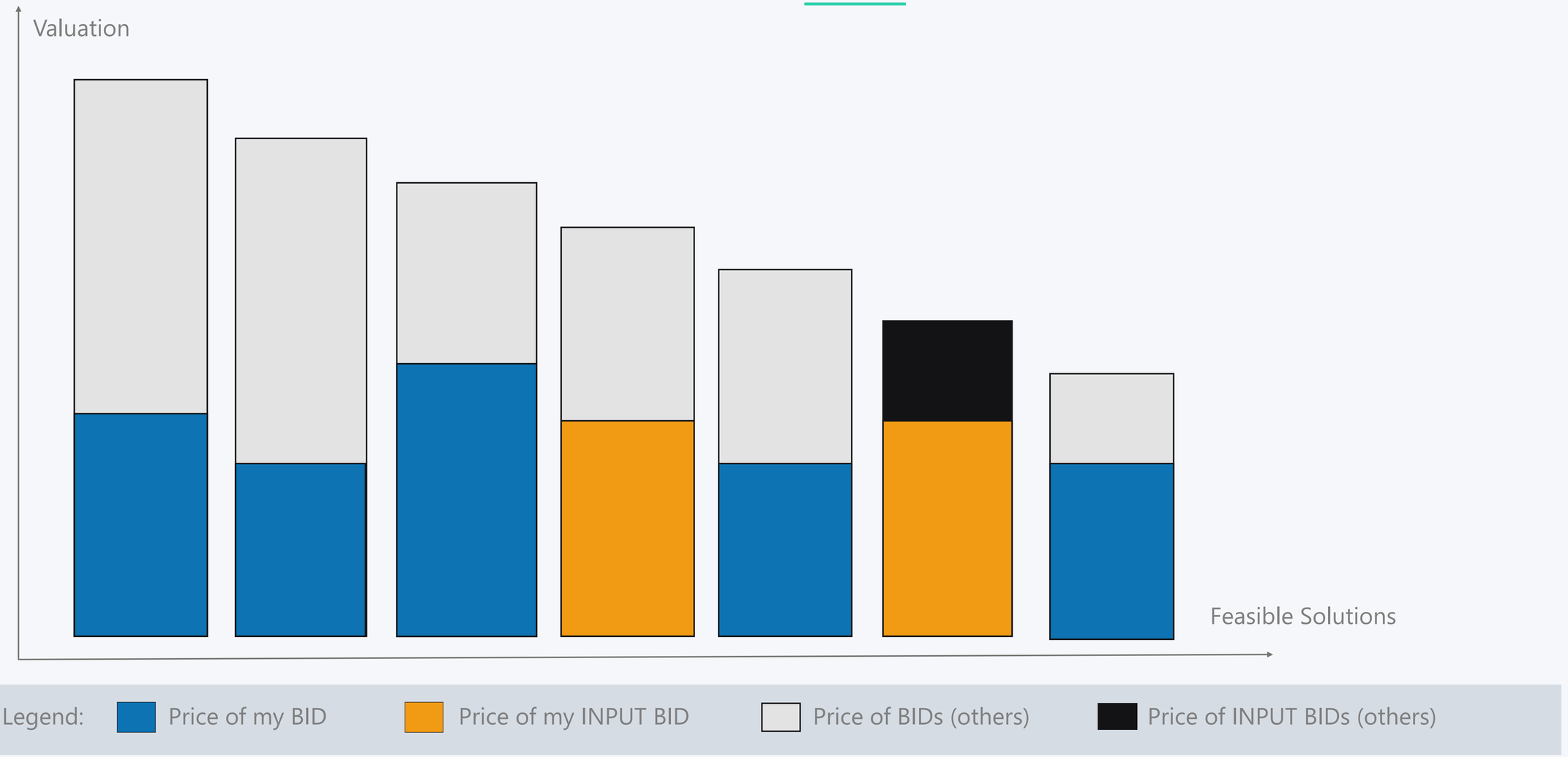
Sale Weight
(Your Input Bid price) / (All Input Bid prices)

Purchase Weight
(Your Winning Bid price) / (All Winning Bid prices)

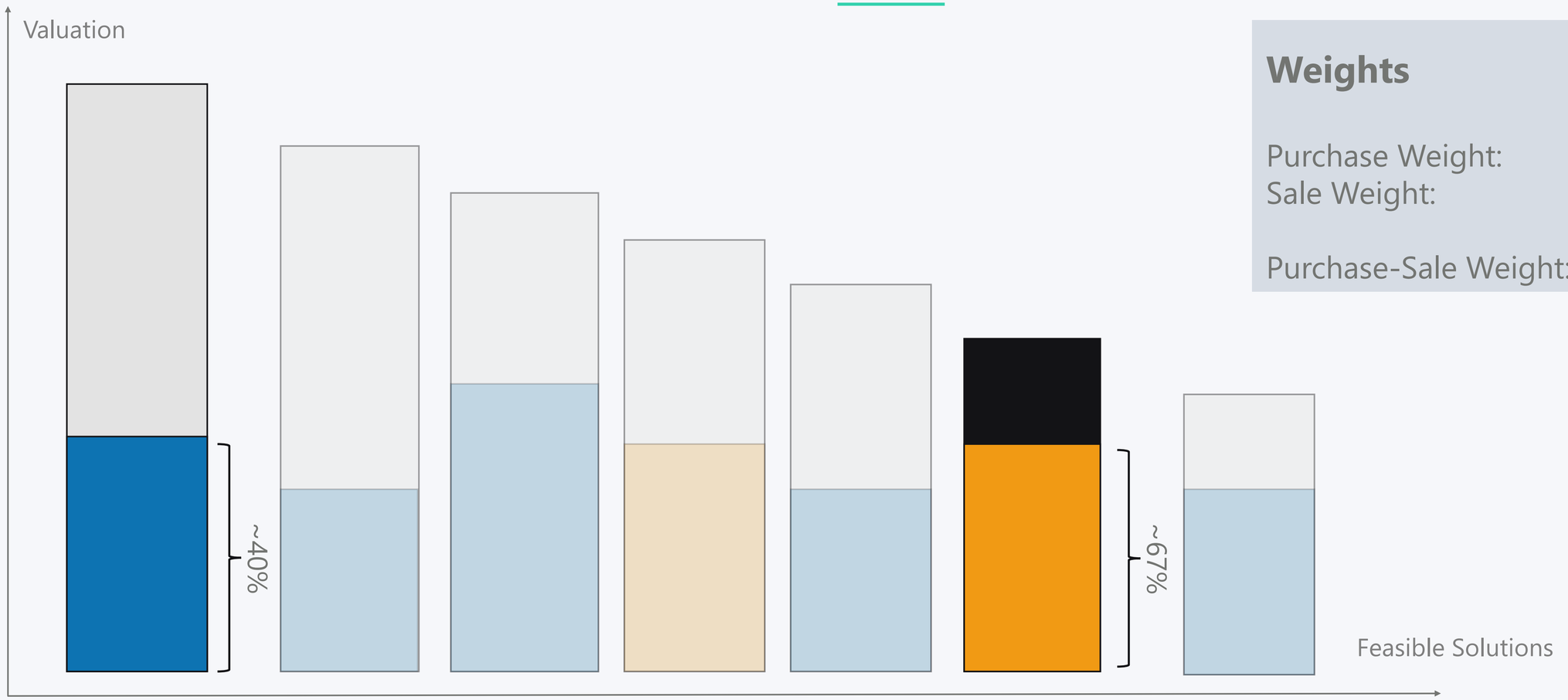
Purchase/Sale Weight
0.5 * (Sales Weight + Purchase Weight)

See [5]

Perspective of Conspiring Bidder



Perspective of Conspiring Bidder

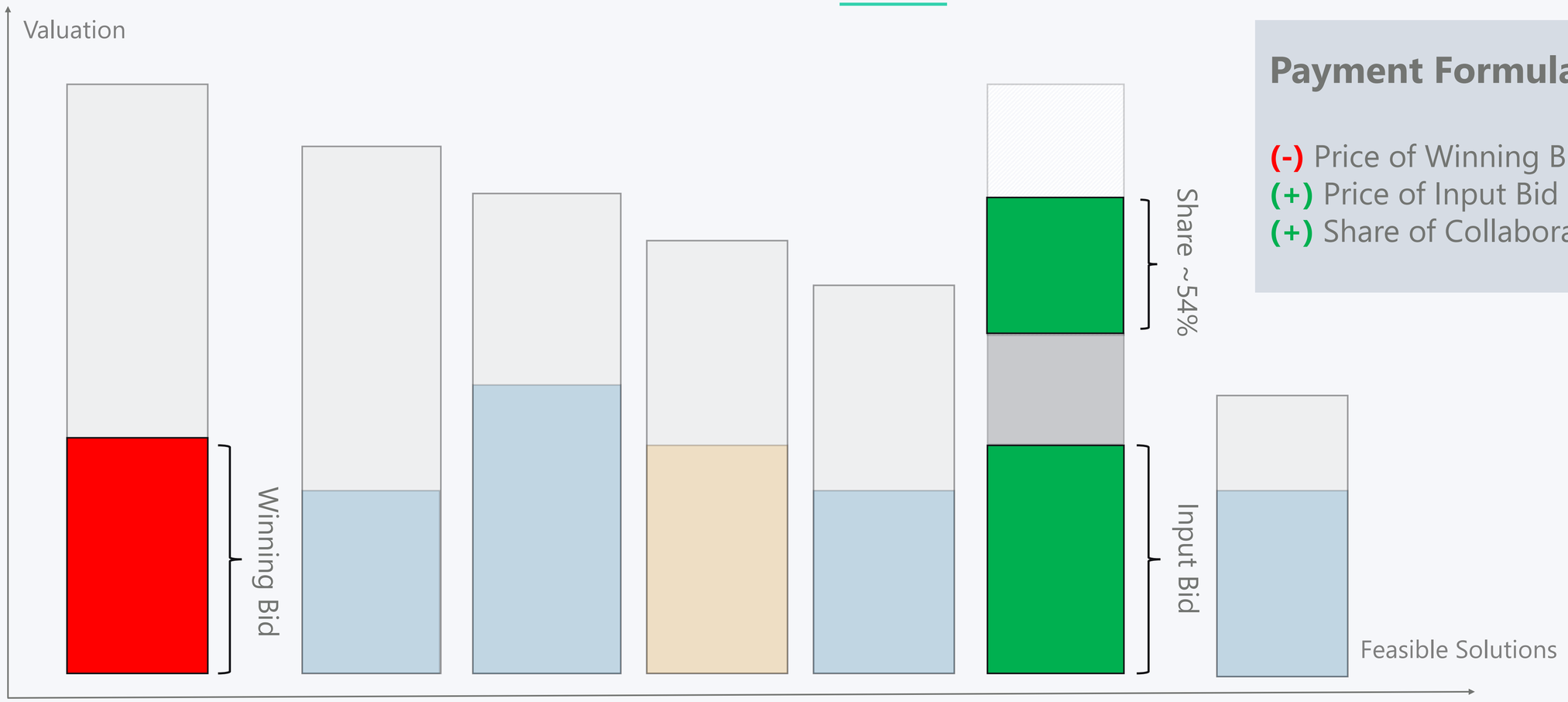


Weights

Purchase Weight:	~40%
Sale Weight:	~67%
Purchase-Sale Weight:	**~54%**

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

Perspective of Conspiring Bidder

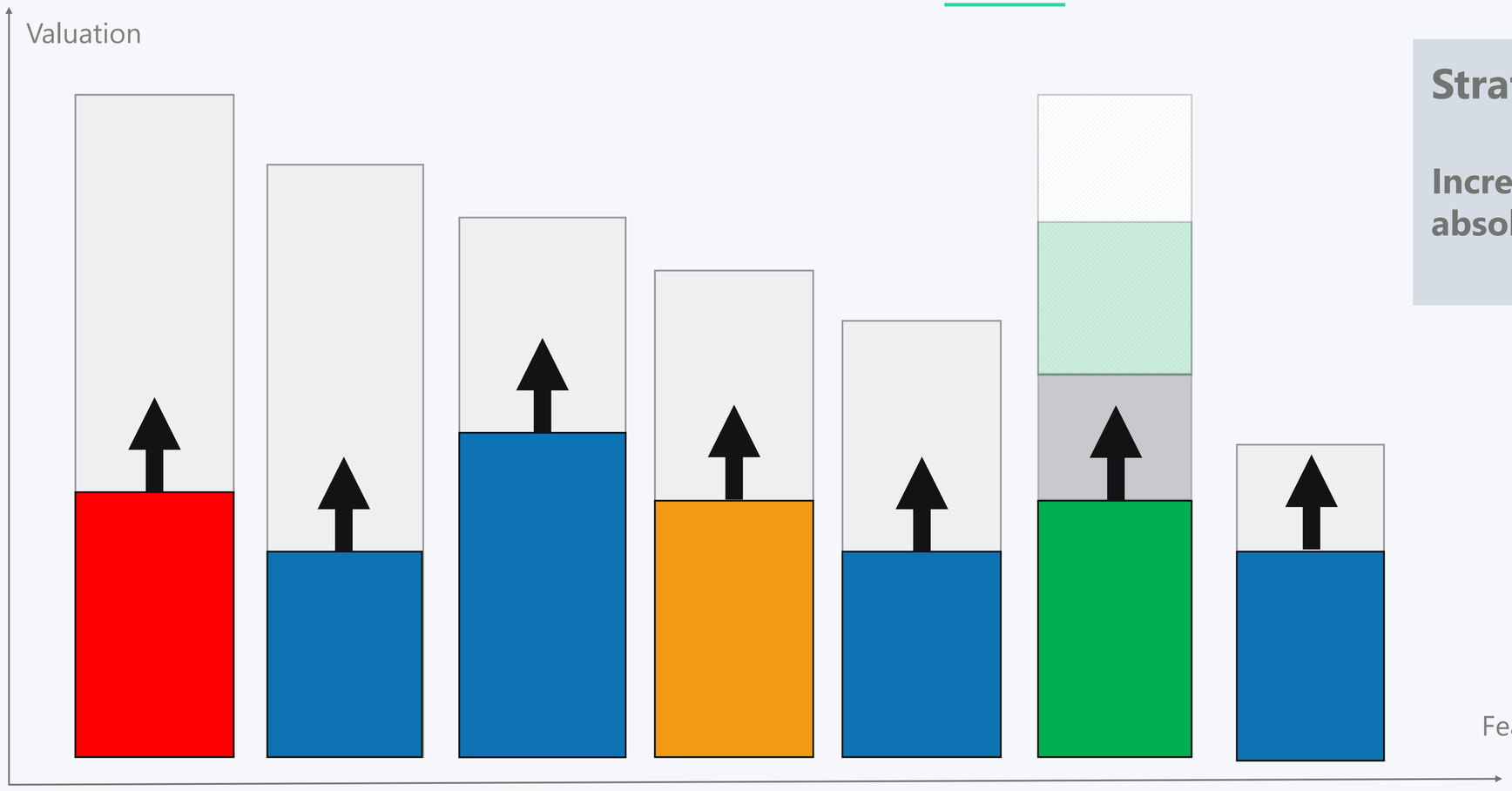


Payment Formula

(-) Price of Winning Bid
(+) Price of Input Bid
(+) Share of Collaboration Gain

Legend: Price of my BID; Price of my INPUT BID; Price of BIDs (others); Price of INPUT BIDs (others); Gain; Loss

Perspective of Conspiring Bidder

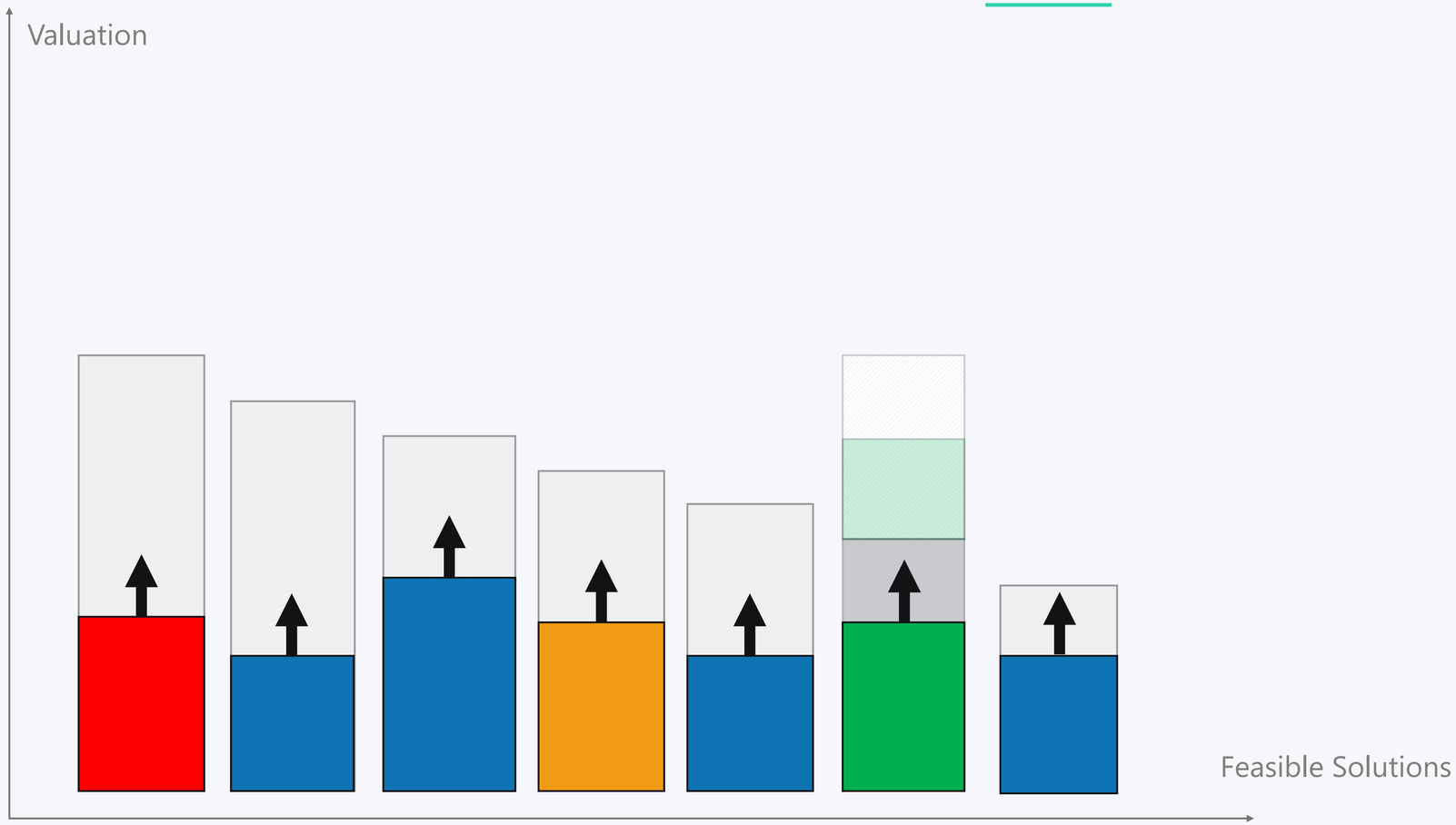


Strategy – HIGH_ABS

Increase prices of all bids by the same absolute margin

Legend: Price of my BID | Price of my INPUT BID | Price of BIDs (others) | Price of INPUT BIDs (others) | Gain | Loss

Perspective of Conspiring Bidder

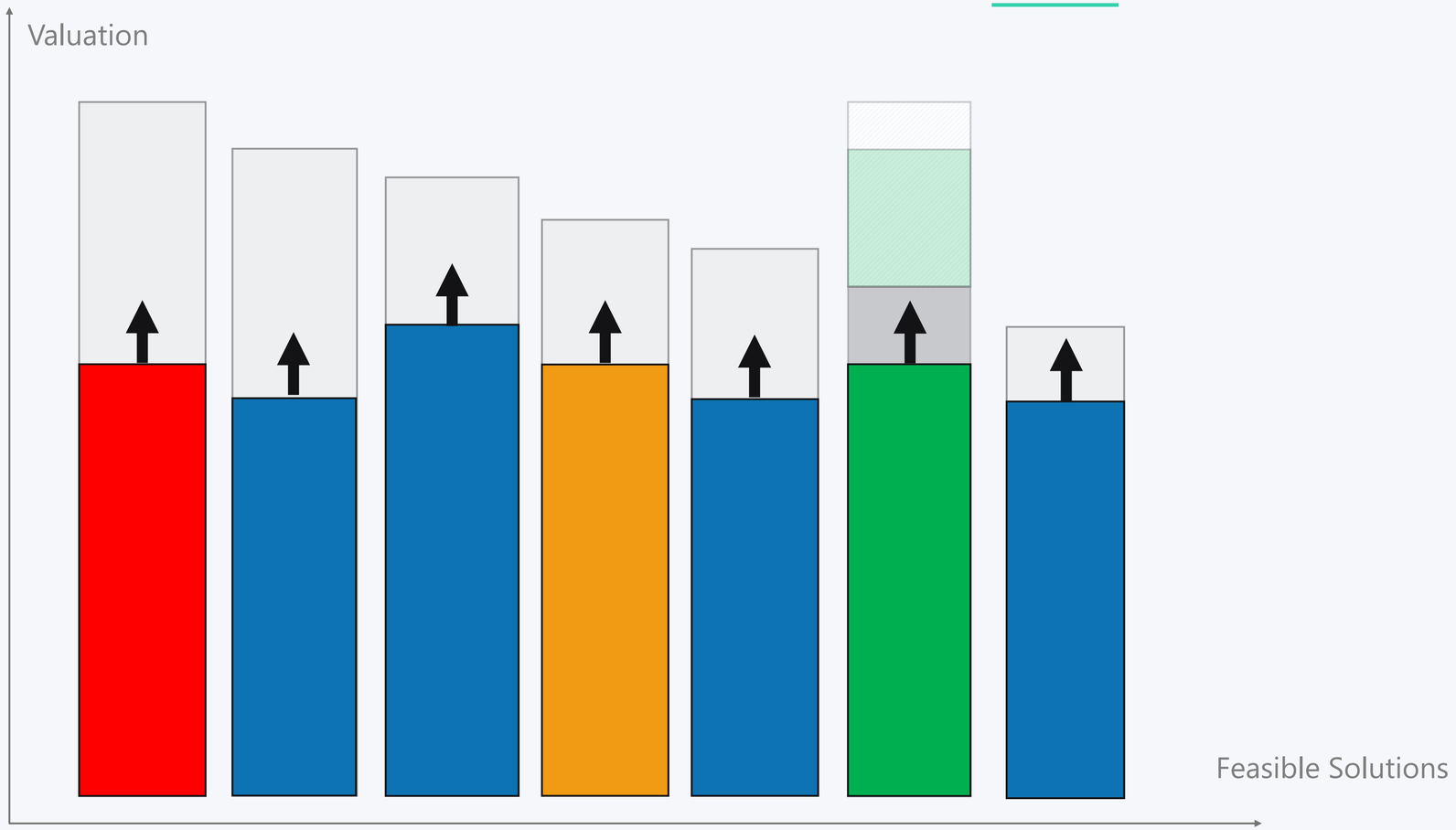


Strategy – HIGH_ABS

Increase prices of all bids by the same absolute margin

Legend: Price of my BID | Price of my INPUT BID | Price of BIDs (others) | Price of INPUT BIDs (others) | Gain | Loss

Perspective of Conspiring Bidder

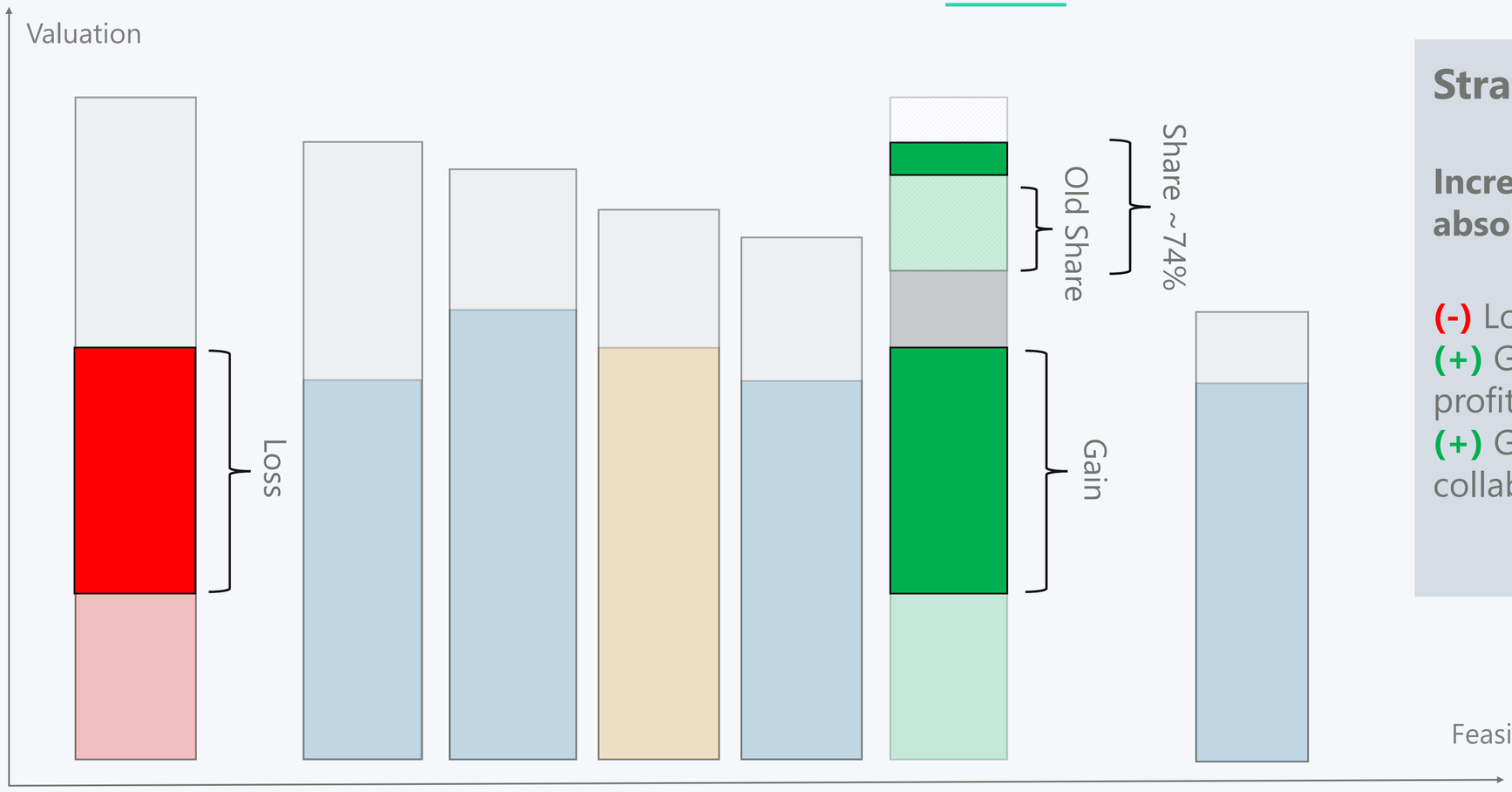


Strategy – HIGH_ABS

Increase prices of all bids by the same absolute margin

Legend: Price of my BID | Price of my INPUT BID | Price of BIDs (others) | Price of INPUT BIDs (others) | Gain | Loss

Perspective of Conspiring Bidder



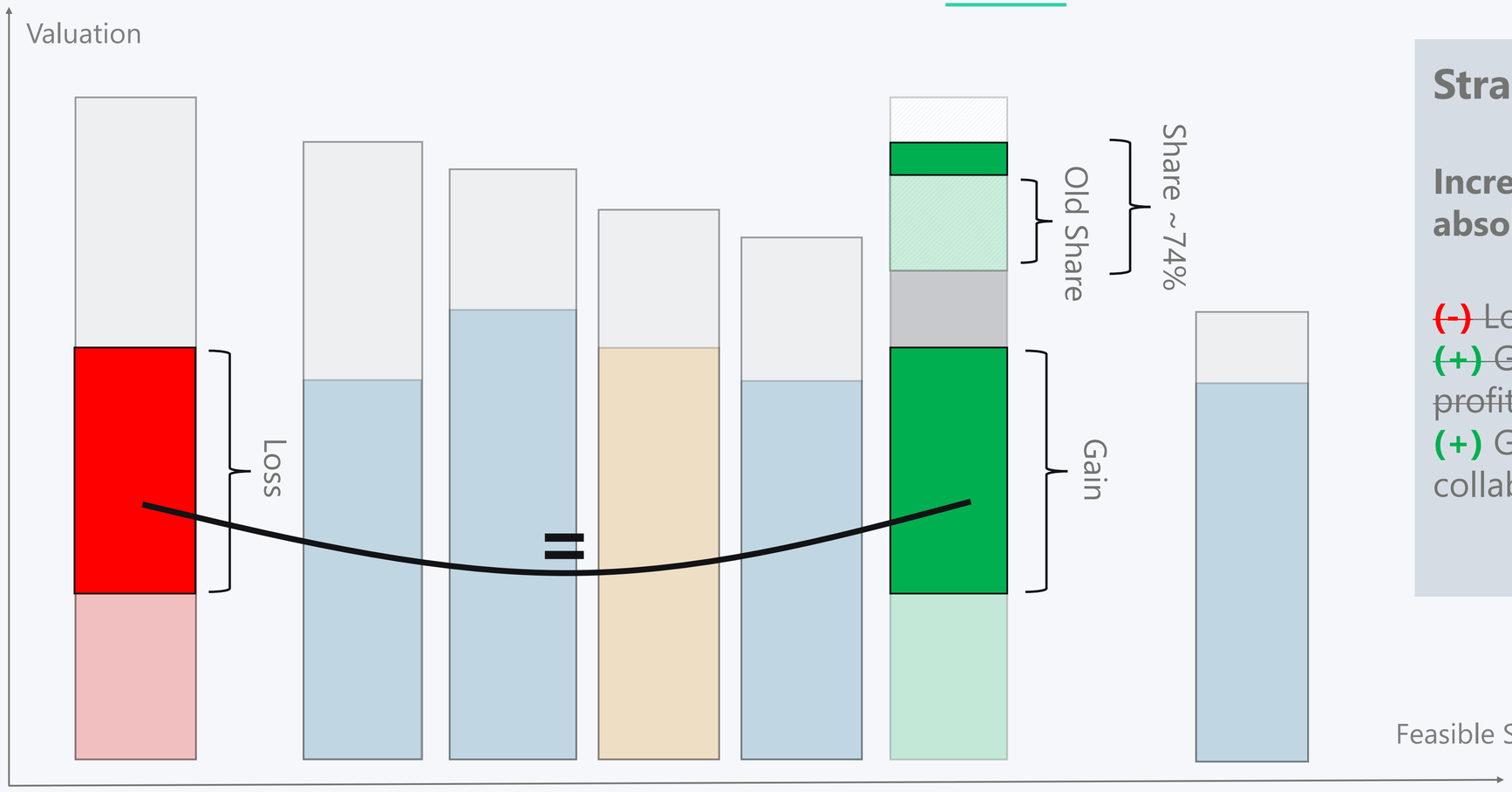
Strategy – HIGH_ABS

Increase prices of all bids by the same absolute margin

(-) Loss of overbidding
(+) Gain from increasing guaranteed profit of Input Bid
(+) Gain from increasing share of collaboration gain

Legend: Price of my BID; Price of my INPUT BID; Price of BIDs (others); Price of INPUT BIDs (others); Gain; Loss

Perspective of Conspiring Bidder



Strategy – HIGH_ABS

Increase prices of all bids by the same absolute margin

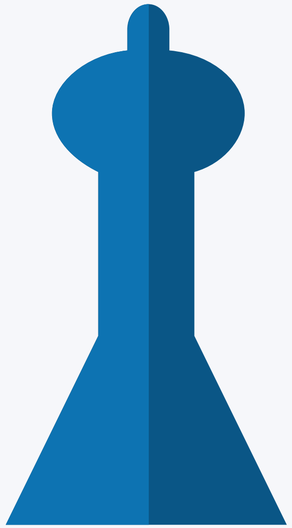
~~(-) Loss of overbidding~~
~~(+) Gain from increasing guaranteed profit of Input Bid~~
(+) Gain from increasing share of collaboration gain

Legend: Price of my BID; Price of my INPUT BID; Price of BIDs (others); Price of INPUT BIDs (others); Gain; Loss

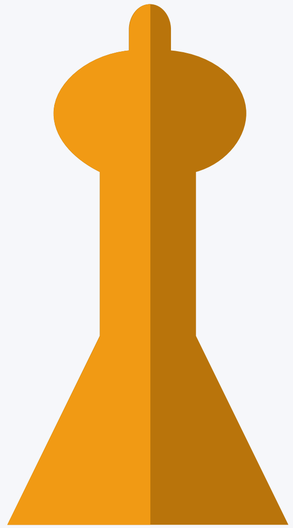
Strategies

Conspiring Bidder Strategies

HIGH_ABS
Increase prices of all bids by the same absolute margin



Strategic Bidder Strategies



HIGH_ABS
Increase prices of all bids by the same absolute margin

Test Results for Strategic Bidder

Result:

Overbidding on all bids by an absolute margin can increase the profit dramatically

Legend: Strategic Bidder | Truthful Bidder | Truthful Bidder