Assessing the Impacts of Preferential Procurement on Low-Carbon Building

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Background

- Building - the largest CO_2 emission contributor in construction
- Preferential bidding

  - Used in public procurement

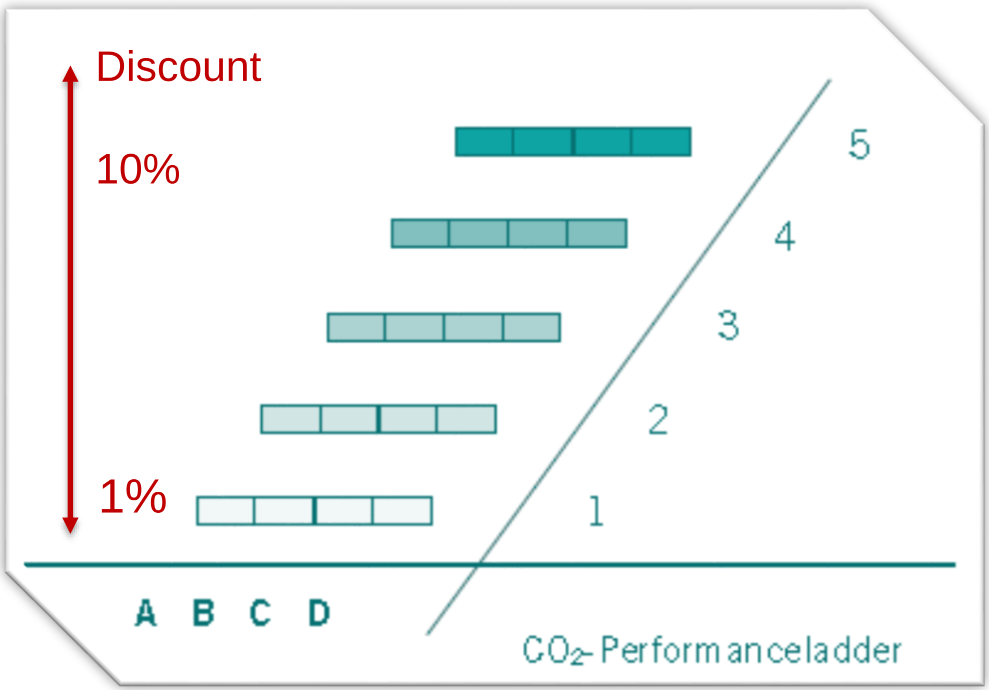
  - Emission saving incentives

  - Integration of favored participants

Bid discount 1% 2%

Current practices

CO_2 Performance Ladder (Netherlands)



Aspects:

A = Insights
B = Reduction ambition
C = transparency
D = participation in CO_2 initiatives

Ref. ProRail, 2009

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Knowledge gap

Incorporation of environmental performance in contract award criteria

- Characterized as "basic environmental requirements"
- Limited attention to climate change issues
- Restrained by immature method for carbon accounting

Ref. Hamza and Greenwood, 2009; Tarantini eat al., 2011; Varnas et al., 2009; Ochoa, 2003 and Erdmenger, 2001

Research needs

New understanding of carbon management in terms of procurement mechanism designs

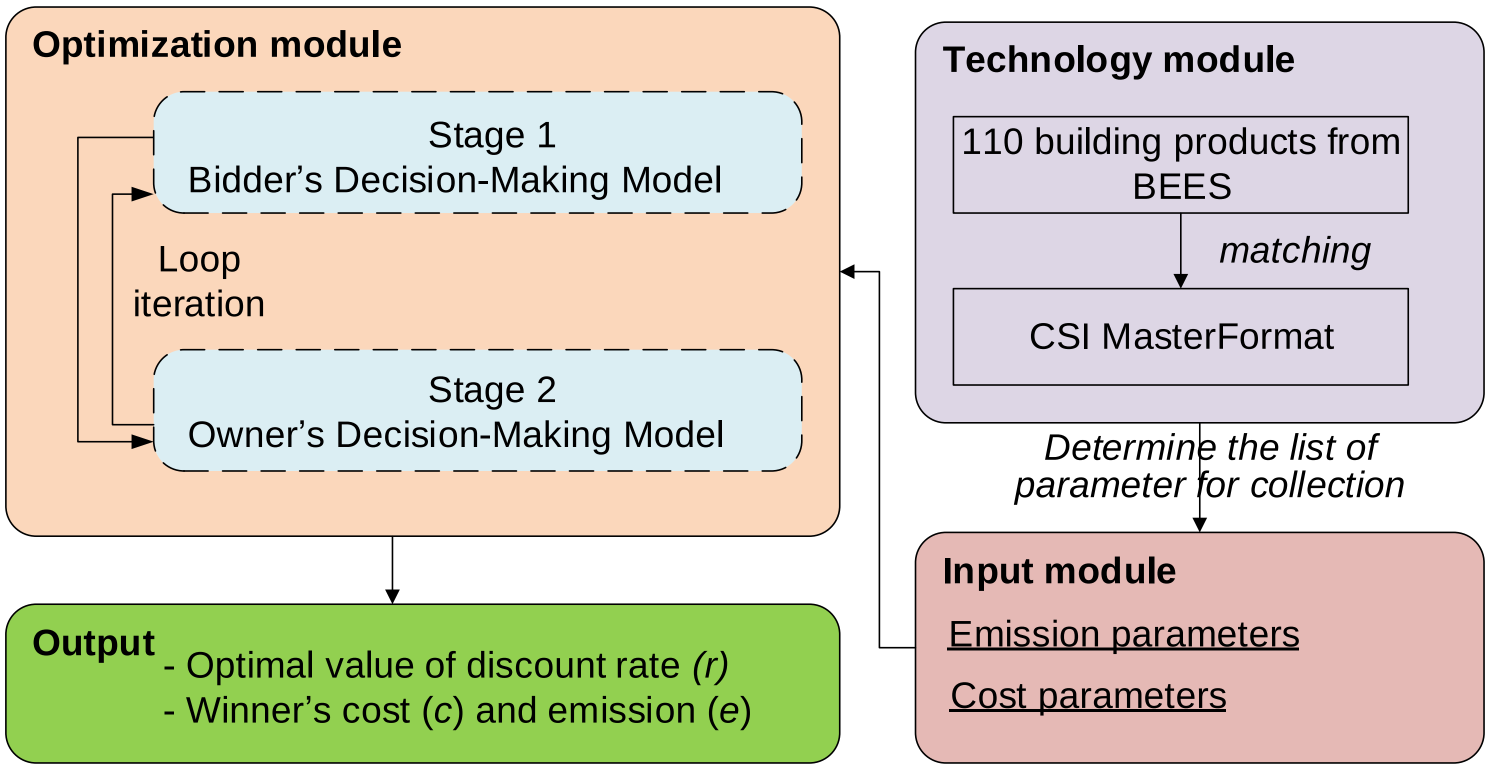
This study aims to:

- Investigate the effects of bid discount on emission reduction
- Optimize the choice of discount level for public agency
- Improve the quantification of building emissions

Optimization problem description

- *N* potential contractors interested in a building project
- A mix of design and performance specification
- Bid is comprised of both cost and emission information
- Bid is discounted based on emission savings
- The winner is paid the full amount of his bid

Decision-making model



Determine the discount rate that automatically controls the emission of the awarded contract within a desired level.

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Modelling bidder's behavior

- First-price sealed-bid auction
- Bidders follow the same bidding strategy, β(·), mapping project cost, c_i, onto a bid b_i, β(·): $[\underline{c}, \overline{c}] \rightarrow [\underline{b}, \overline{b}]$.

Bayesian-Nash equilibrium

$$b_i(\bar{c}_i) = c_i \cdot \left(\frac{n\delta_i + 1}{n\delta_i}\right)$$

in which

b_i represents the bid for bidder *i* before the discount

δ_i represents the bid discount for bidder *i*

Ref. Ausubel, 2003

Modelling owner's behavior

- Scoring technique
- An optimal value of $\hat{r}$ that achieves an optimal cost-emission allocation

Social welfare function $$\max_{r} PS(\mathrm{r}) = \left(\frac{c_0 - c_k}{c_0} + \frac{e_0 - e_k}{e_0}\right)$$

Cost saving | Emission saving

s.t.

$$\mathrm{c}_k = \overline{\mathrm{b}}_k \cdot (1 + \delta_k)$$

$$\overline{\mathrm{b}}_k = \min \left\{ \overline{b}_i \right\}_{i=1,\dots,N}$$

$$e_k = \sum_{m,k} g_{m,k} q_{m,k} + \sum_{c} \sum_{n} \varphi_{\mathrm{c,n,k}} g_{\mathrm{c,n,k}} q_{\mathrm{c,n,k}}$$

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Case study

- A building retrofit project conducted in Virginia
- Work includes:

Design Specification	Performance Specification
Division 4 Masonry	Division 3 Concrete
Division 5 Metals	Division 6 Wood
Division 8 Openings	Division 7 Thermal and moisture
Division 23 Heating and ventilation	Division 9 Finishes
Division 26 Electrical	Division 32 Exterior improvements

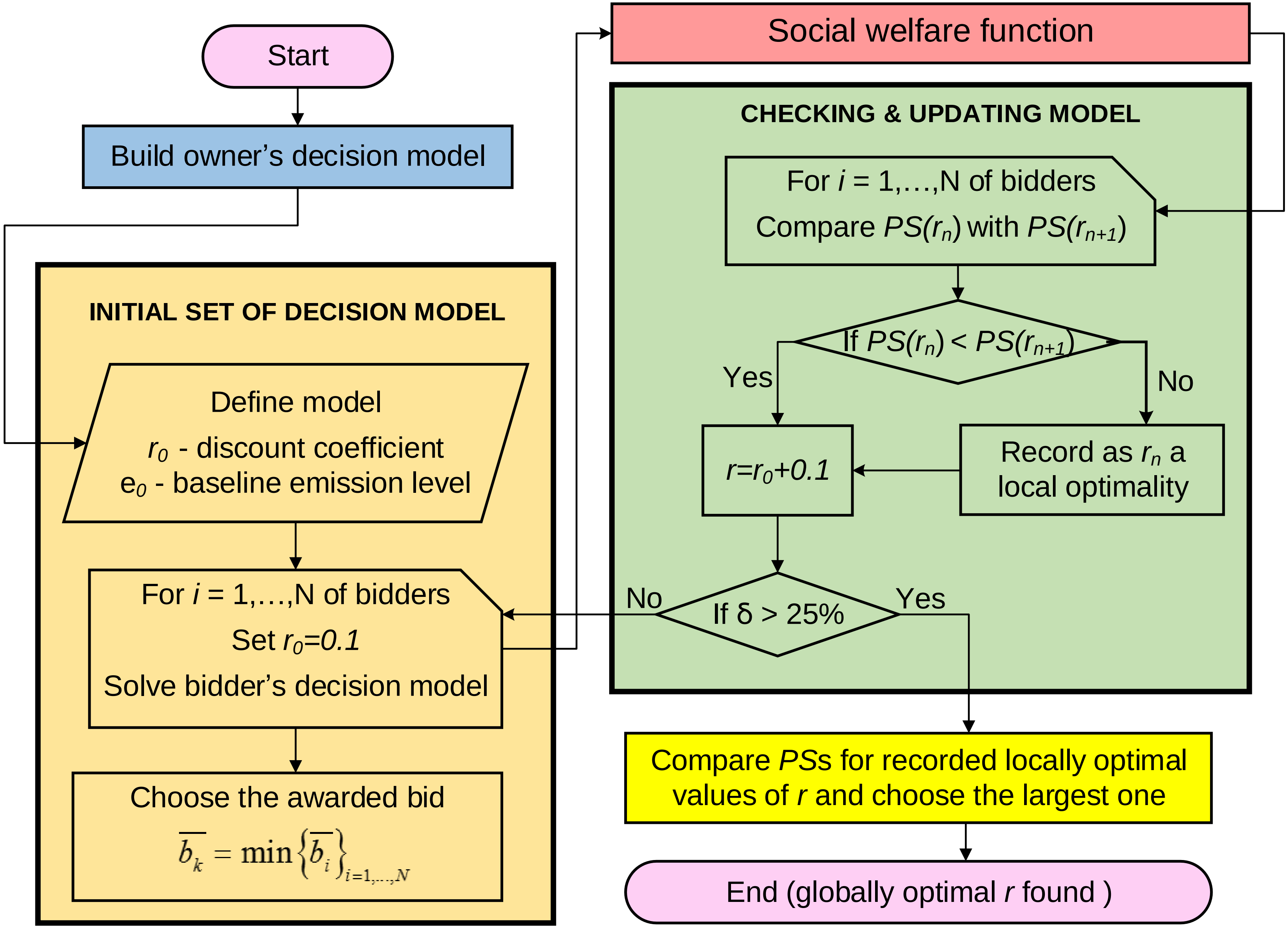
Bidders have the flexibility to choose design alternatives

Basic assumptions

- Owner determined the emission benchmark and the baseline procurement costs for the “performance-based” divisions
- Bidders’ costs and emissions for the “design-based” divisions are the same
- Individual bidders cannot obtain access to all of the design alternatives

	Price $/ft^2$	gCO_2/ft^2	Bidder 1	Bidder 2	Bidder 3
1. Framing					
1.1 Generic wood framing-treated*	2.07	318	X	X	X
1.2 Generic wood framing-untreated	2.68	201	X		X
2. Ceiling insulation					
2.1 Generic Blown Mineral Wool R-38*	1.39	188	X	X	X
2.2 Generic Blown Celluloose R-38	2.19	179	X	X	
2.3 Generic Blown Fiberglass R-38	1.53	190		X	X
3. Interior wall finishes					
3.1 Generic consolidated	0.67	75	X	X	
3.2 Generic reprocessed latex paint	0.67	119		X	X
3.3 Generic virgin latex*	0.76	230	X		X
4. Interior partitions					
4.1 P&M Altree panels*	7.2	1,992	X	X	X
4.2 Trespa Athlon panels	7.75	1,175	X	X	X
5. Concrete pad					
5.1 Generic 15% Fly Ash Cement*	1.73	3,958	X		X
5.2 Generic 20% Slag Cement	1.77	3,889	X		
5.3 Generic 35% Slag Cement	1.74	3,595		X	
5.4 Lafarge Portland Type I Cement	1.81	3,185	X	X	
5.5 Lafarge NewCem Slag Cement (20%)	1.77	3,910			X
5.6 Lafarge NewCem Slag Cement (35%)	1.74	3,626			X

Building product alternatives for bidders



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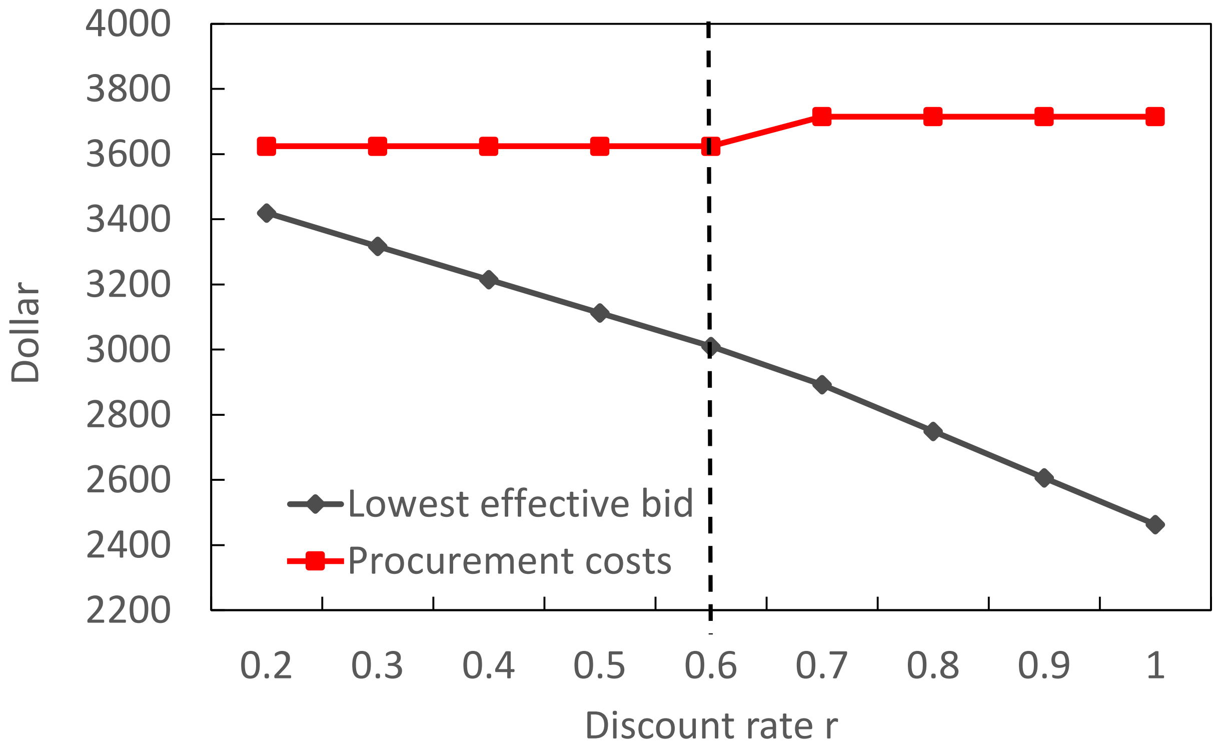
Modelling results

	Baseline	0.1<r≤0.6	r>0.6
GHG emissions (MT)	8.57	6.15	6.11
Procurement costs ($)	3,494	3,624	3,715
MTCO_2e reduction per dollar	0	0.02	0.01

Given a 0.6 discount rate, the emissions from the awarded contract can be reduced by 28.2%, while the procurement costs increase by 3.7%.

Modelling results



r = 0.6 is the highest among all of the feasible *r* values that enable the owner to achieve a maximum social welfare function

Conclusion

- The model provides a generally applicable tool that enables owners to tailor the bid discount to any building project
- For the building retrofit project studied herein, a discount rate of 0.6 can be offered to reduce CO_2 emissions by 28.2% but increases procurement costs by 3.7% relative to no intervention
- The framework for predicting behavioral patterns and making decisions is pertinent to other types of projects in which preferential policies are used

Thanks for your attention!

Welcome any comments and suggestions!

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