



# A Novel Incentive-based Retail Demand Response Program for Collaborative Participation of Small Customers



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## Main Focus

- Wholesale market integrated DR programs: aggregators should minimize risk of insufficient response.
- Constant incentives, nor individual performance-based incentives effectively reflect needs of aggregators.
- Development of a novel retail demand response program: incentives are dependent on the aggregated performance of all participants.

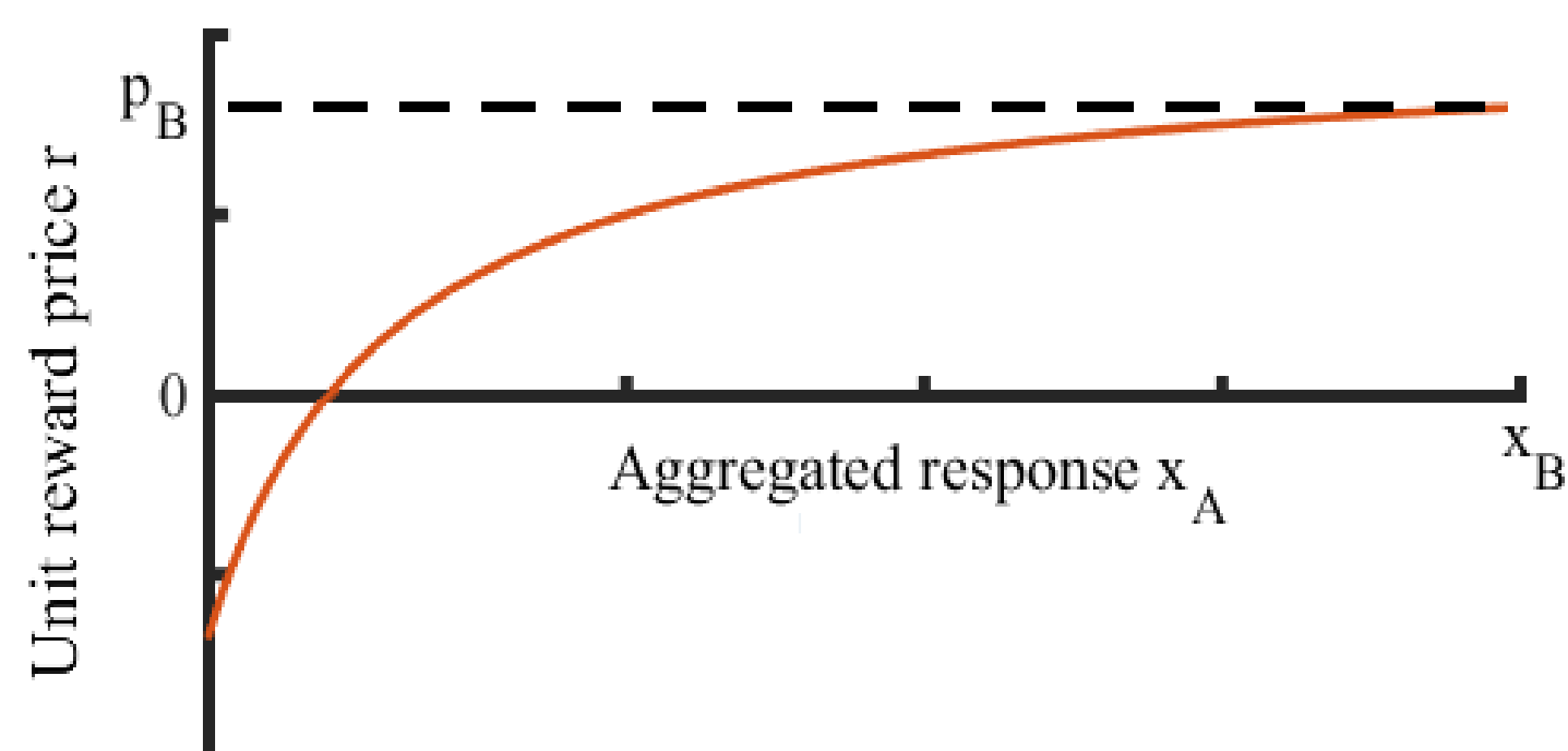
## Approach

- Offer customers incentive based on fair share (FS) of profit of the aggregator.
- Game theoretic analysis:
  - Guaranteed reward  $C_g > 0$
  - unit reward  $r$  strictly increasing with aggregated response  $x_A$
- Mechanism below triggers snowball effect  $\rightarrow$  naturally effect aggregated shift  $x_A(r)$  and unit reward  $r(x_A)$  are positively correlated.

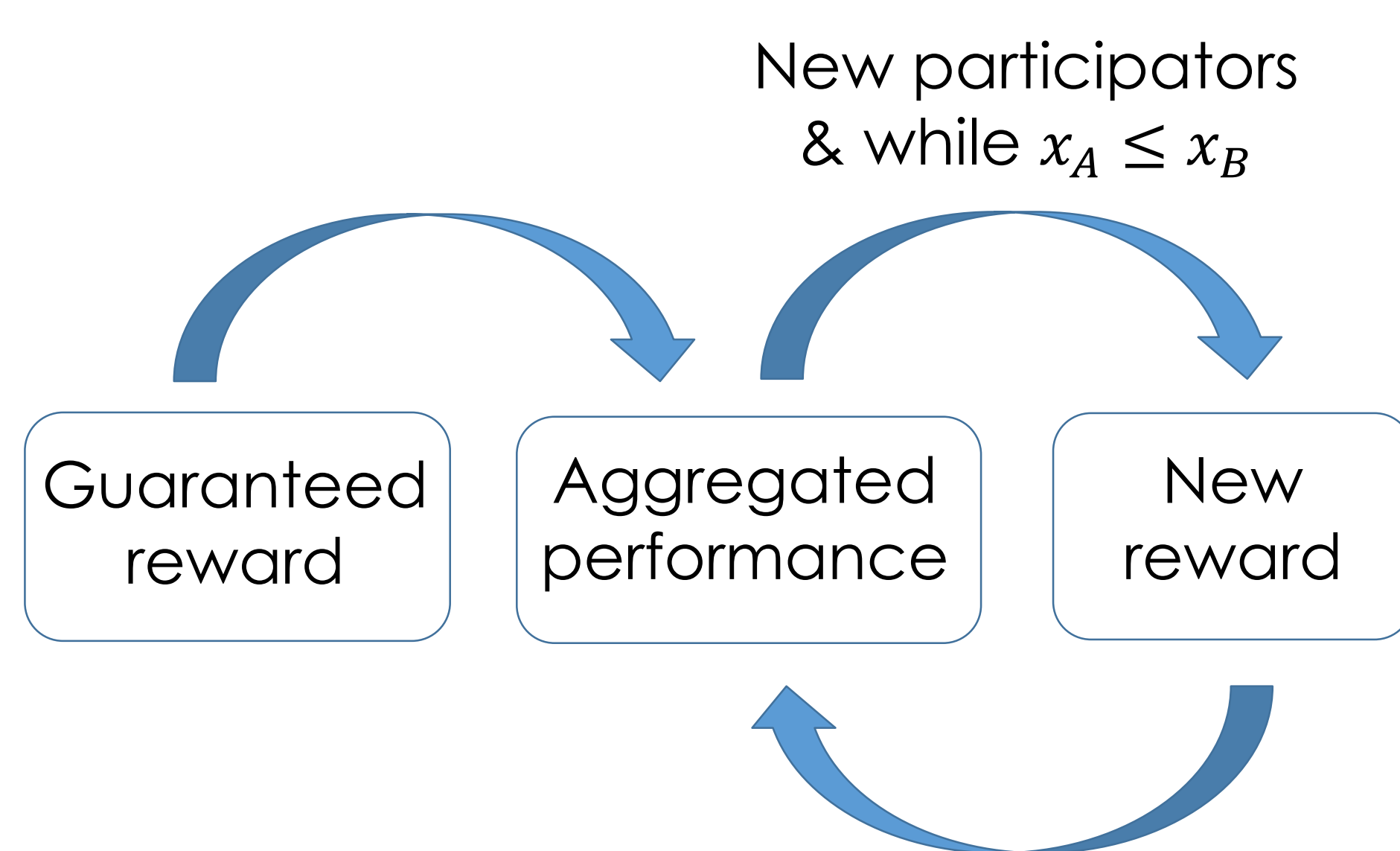
## Fair share incentive

$$FS_i = \frac{|x_i|}{|x_A|} \times (|x_B| \times p_B - |x_B - x_A| \times p_P) \quad |x_A| \leq |x_B|$$

$x_A$ : Aggregated performance |  $p_B$ : Bid price  
 $x_B$ : Bid amount |  $p_P$ : Penalty price  
 $x_i$ : Individual performance |  $FS_i$ : Fair share



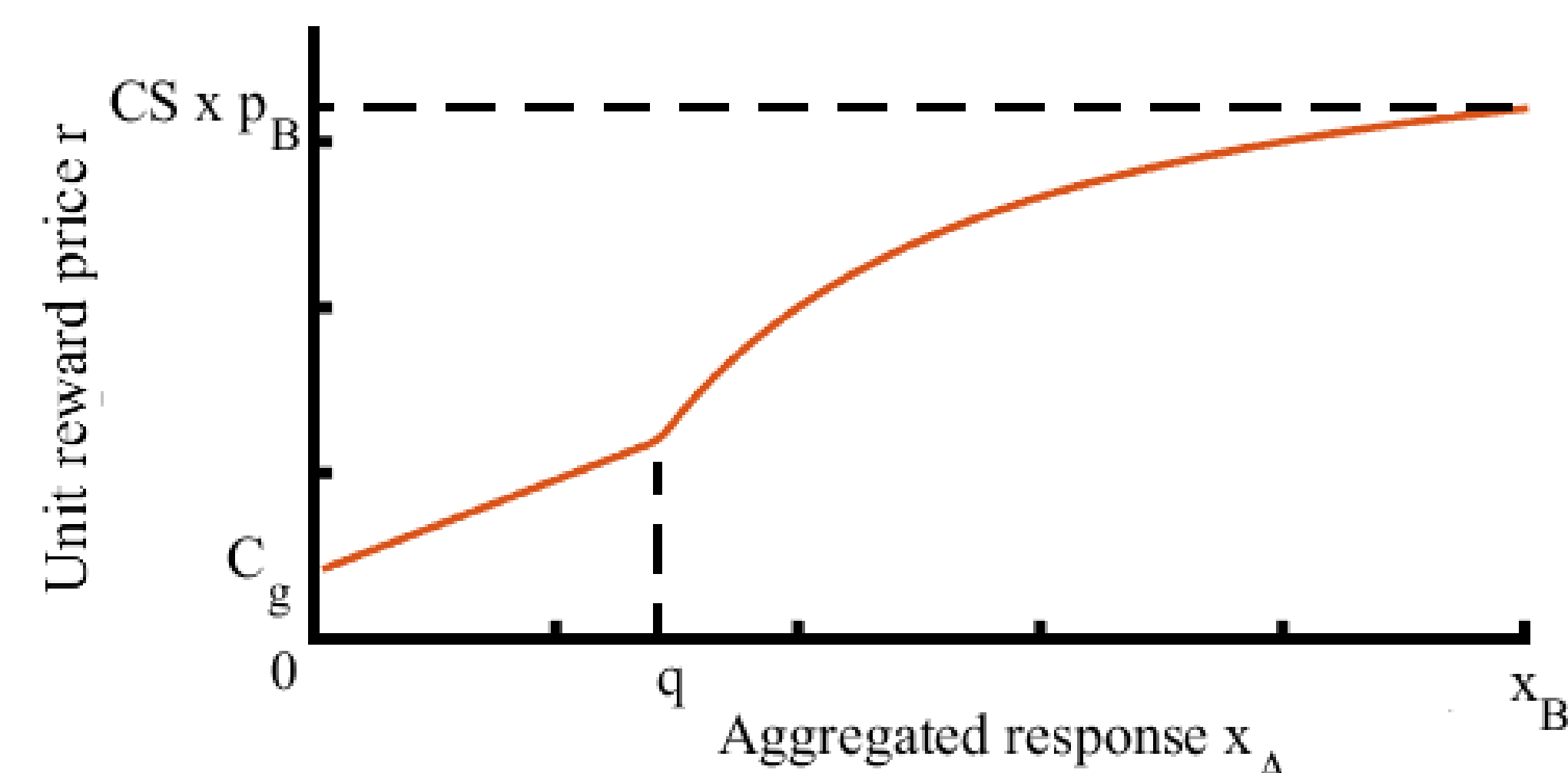
## Snowball effect mechanism



## Adjusted incentive

$$r(x_A) = \begin{cases} C_g + \frac{CS \times p_B - C_g}{x_B} \times x_A & 0 < |x_A| < q \\ CS \times \left( \frac{|x_B|}{|x_A|} \times p_B + \frac{|x_A - x_B|}{|x_A|} \times p_P \right) & q \leq |x_A| \leq |x_B| \end{cases}$$

CS: Customer share |  $C_g$ : Guaranteed reward



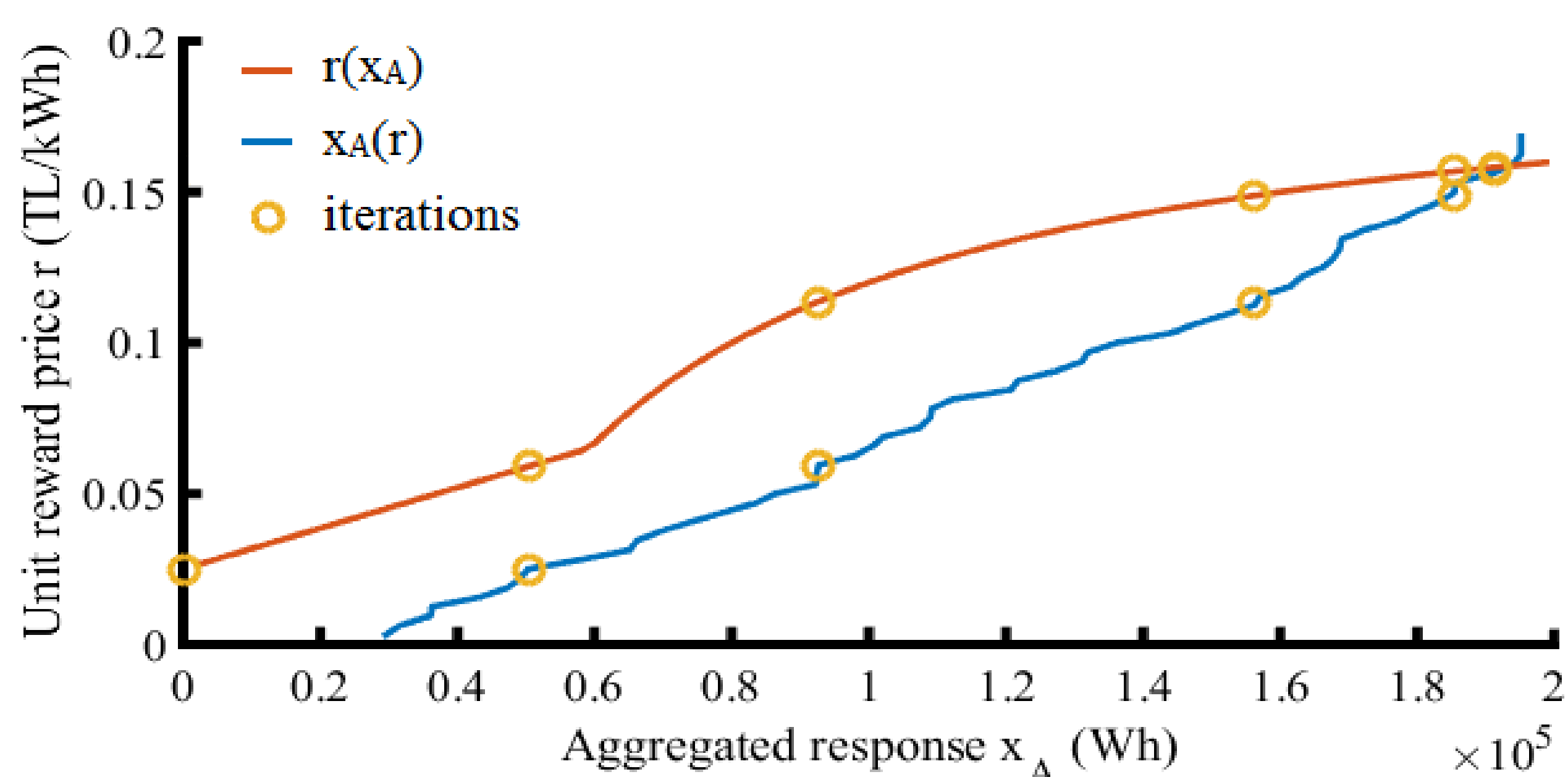
## Modeling

- Flexible device models (shiftable, thermal and neutral)
- Consumer decision making, considering economic benefits, comfort reduction and user preferences
- Use of real market data

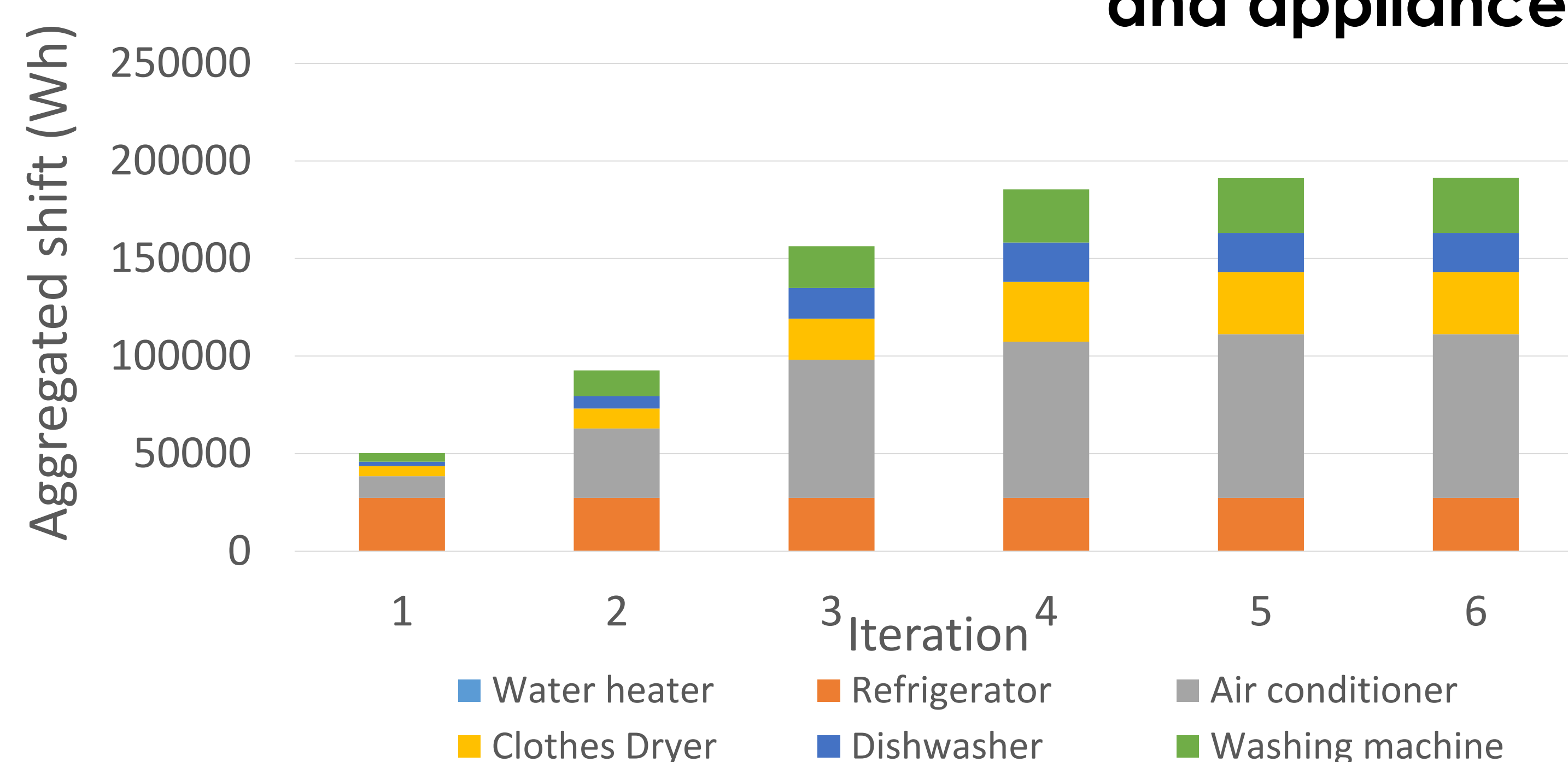
## Simulation

- 2000 households and with 6 types of randomly distributed flexible appliances
- Several DR options for each of the appliances
- A DR-signal for 1 hour (6.00 p.m. to 7.00 p.m.)

## Snowball effect converging in 6 iterations



## Aggregated shift per iteration and appliance



## Conclusions

- The novel program is fair and effective at
  - increasing the number of participators
  - achieving an aggregation performance close to the bidden amount.
- Only small number of iterations is needed (6 for case study) without encountering any overpricing issues.
- Reflection of aggregated performance on incentives helps
  - mitigating the response gap
  - provide more effective response performance.

### FUTURE WORK

- Study
  - real time gamified deployment of DR
  - network topology considered DR applications

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