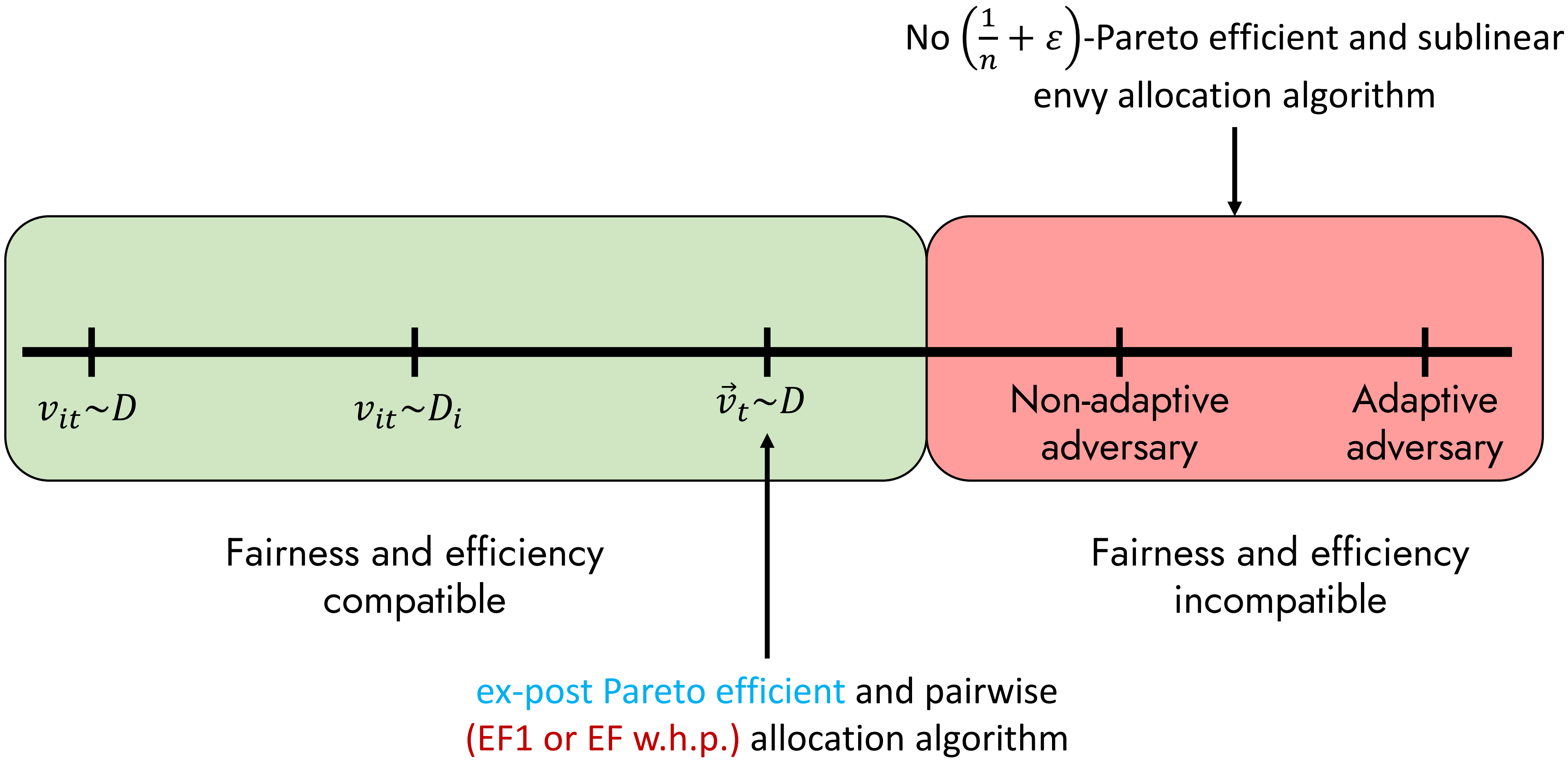
Fairness-Efficiency Tradeoffs in Dynamic Fair Division

David Zeng, Alex Psomas

- T items arrive online, n agents
- Agent i has value $v_{it} \in [0,1]$ for item t that we learn when the item arrives
- Item must be allocated immediately and irrevocably
- After T rounds, we will have some allocation $A = (A_1, \dots, A_n)$
- Additive valuations: $v_i(A_j) = \sum_{g_t \in A_j} v_{it}$
- Ideally, allocation is both fair and efficient

Adversary Model and Results



Algorithm for Correlated Agents ($\vec{v}_t \sim D$)

- Reduce finding a
  - online ex-post Pareto efficient and (EF1 or EF w.h.p.) allocation algorithm to finding a
  - offline Pareto efficient and CISEF fractional allocation
- Algorithm sketch
  - Given online problem and distribution D with support $\{\gamma_1, \ldots, \gamma_m\}$, use the support of D as the items for offline problem, scaling by the probabilities.
  - Use the fractional allocation X to guide our allocation in the online problem.
    - If $X_{ik} = 0.4$, if the item arriving at time t has type γ_k, allocate the item to agent i with probability 0.4
    - Treat cliques as one combined agent when doing randomized allocation
    - When item is allocated to the clique, give to unhappiest agent in clique

CISEF

- CISEF
  - Either agent i strictly prefers her own bundle to the bundle of agent j
  - Or i and j have identical allocations and the same value (up to a scaling factor) for all the items that are allocated to either of them
- How to find CISEF and Pareto efficient allocation?
  - Start with solution to Eisenberg-Gale convex program
  - If agent i is indifferent to agent j, (carefully) move items from j to i to create strong envy-free edges