Markets or Patents? Experiments on Collective Innovation and Information Aggregation

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Agenda

- Background
- Experiments
  1. Incentives for innovation
  2. Markets as oracles
- Summary

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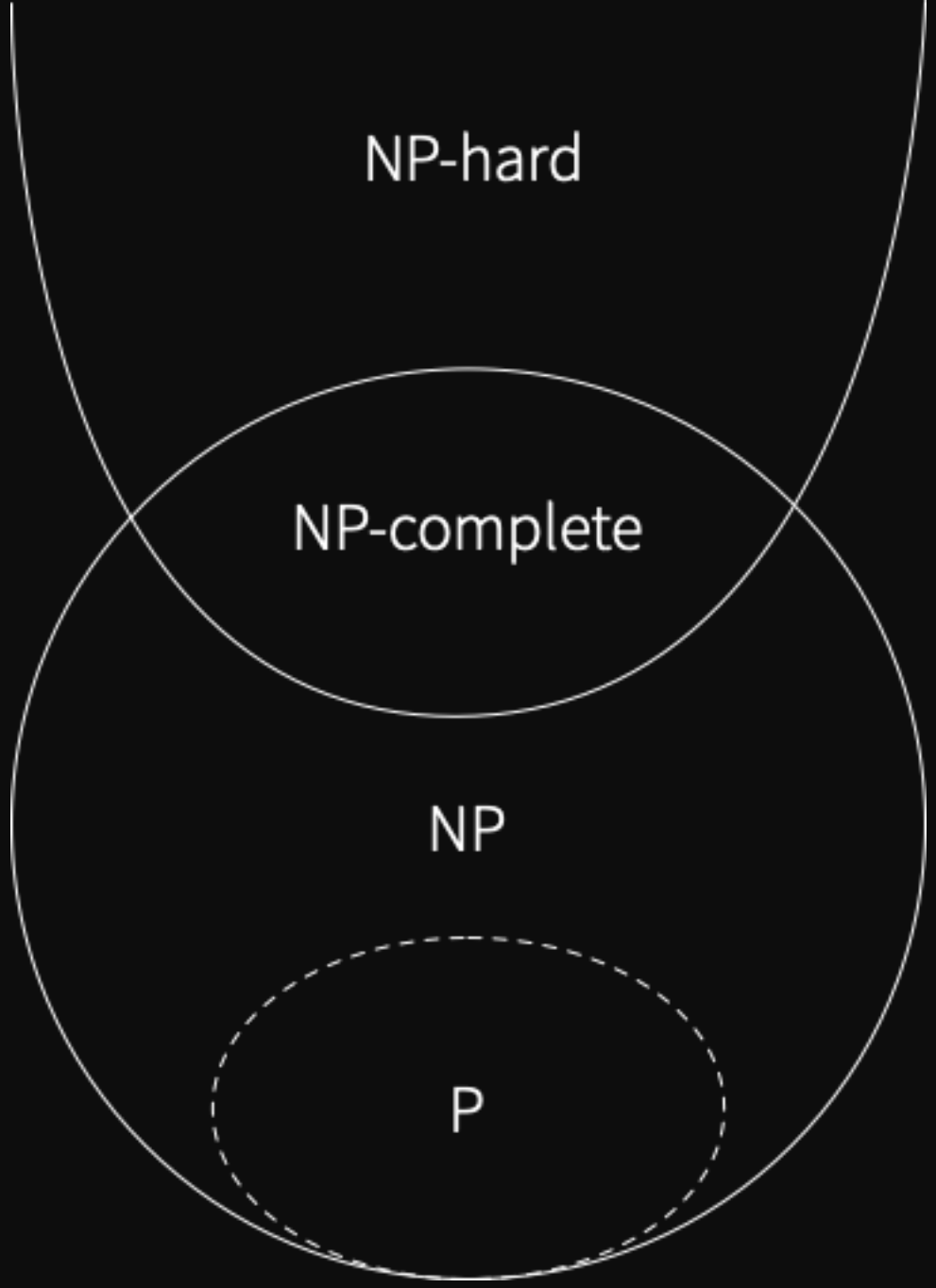
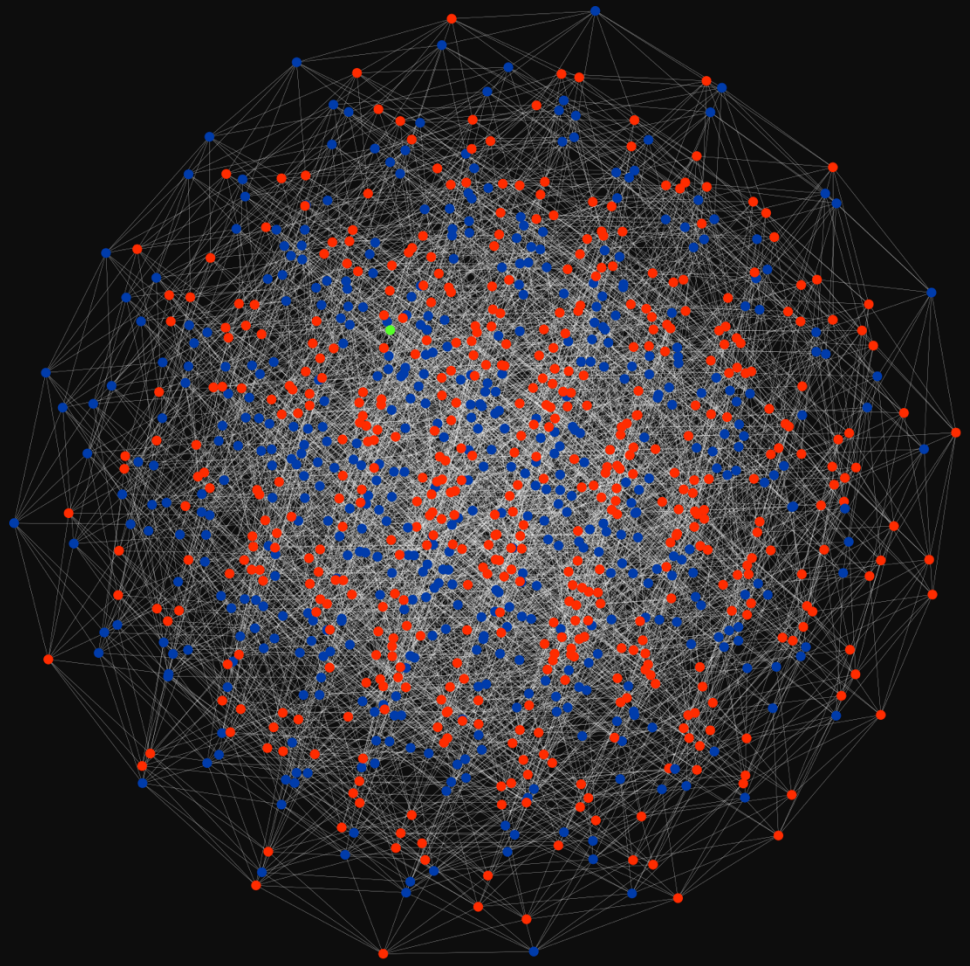


Innovation problems resemble combinatorial search tasks.

These tasks belong to the class of NP-hard problems.

Individuals face cognitive limits in exploring large solution spaces

But collectives can approximate solutions by dividing search effort

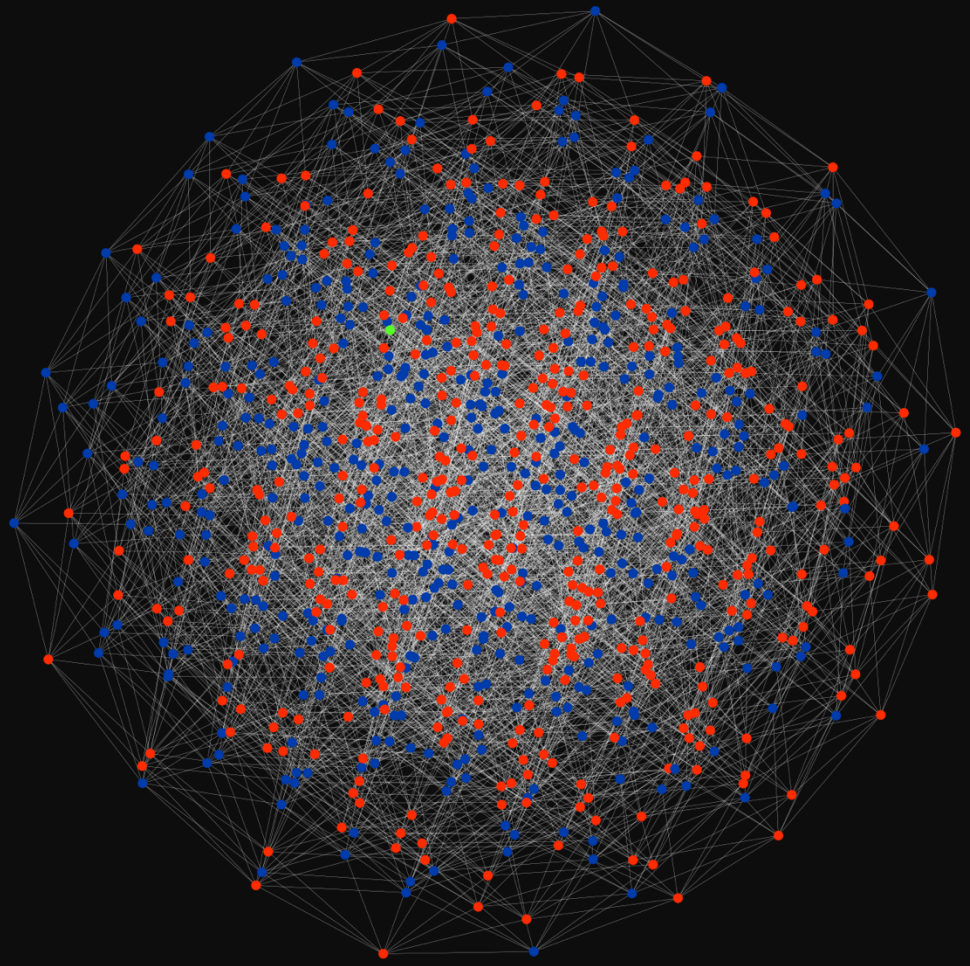


Infeasible nodes Feasible nodes Optimal node

We analogise the innovation process by using the knapsack problem (KP), a canonically complex task.

$$\max \sum_{i=1}^{n} p_i x_i \qquad \text{s.t.} \qquad \sum_{i=1}^{n} w_i x_i \leq C$$

- $W = \{w_1, \ldots, w_n\}$, weight vector
- $P = \{p_1, \ldots, p_n\}$, profit vector
- $C =$ capacity constraint



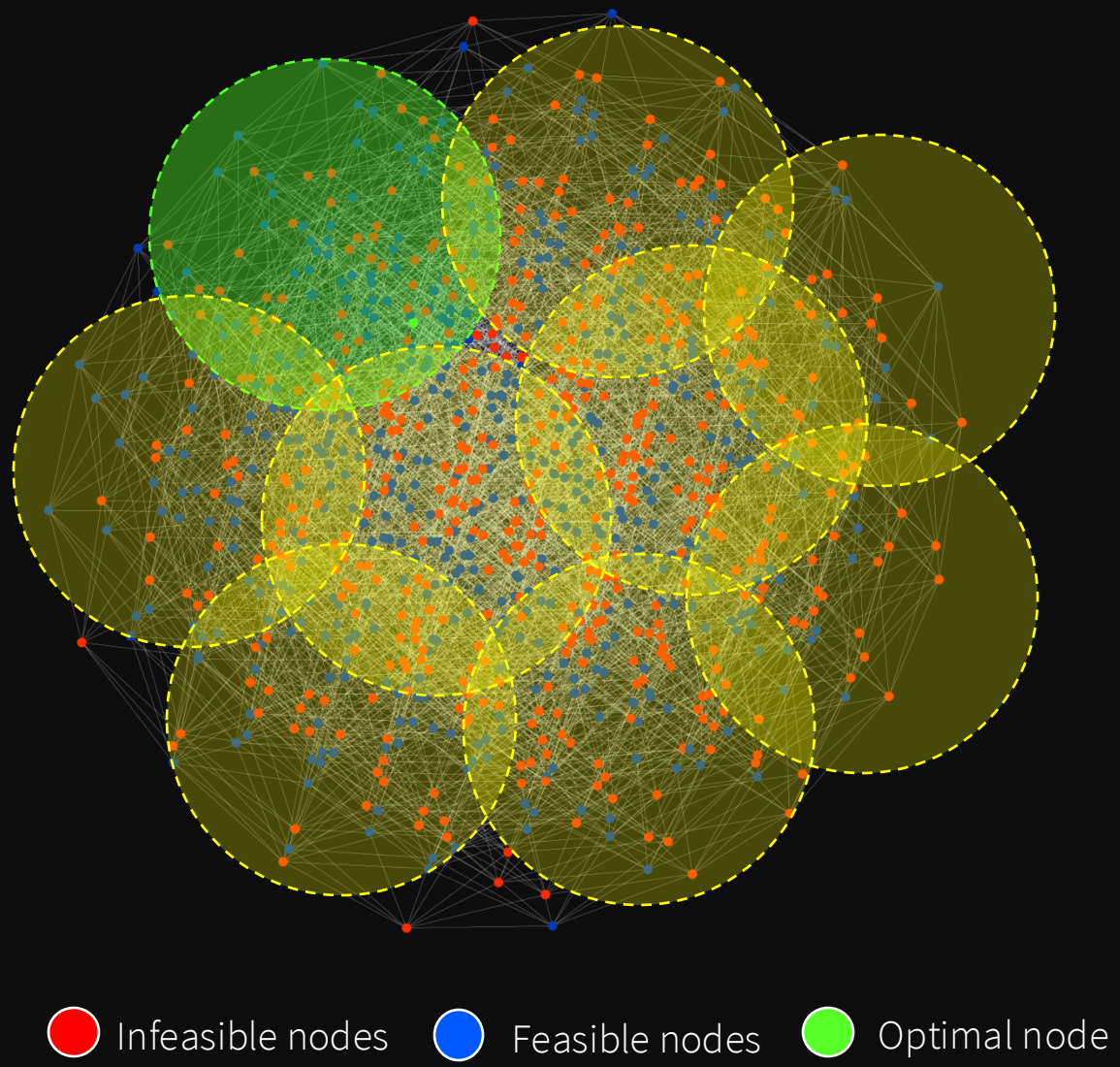
Infeasible nodes Feasible nodes Optimal node

Problem: The total solution space is too vast to exhaustively explore.

Compromise: Individuals try to strike a balance between:

- **Solution quality** – the resulting solution should be within ϵ of the optimum.
- **Frugality** – computational cost should be minimised.

Result: Search over constrained subset of total solution space.



A single individual explores a small subset of the solution space.

A group of individuals collectively explore a large portion of the solution space.

How do we incentivise individuals to communicate and **share knowledge**?

Pilot experiment

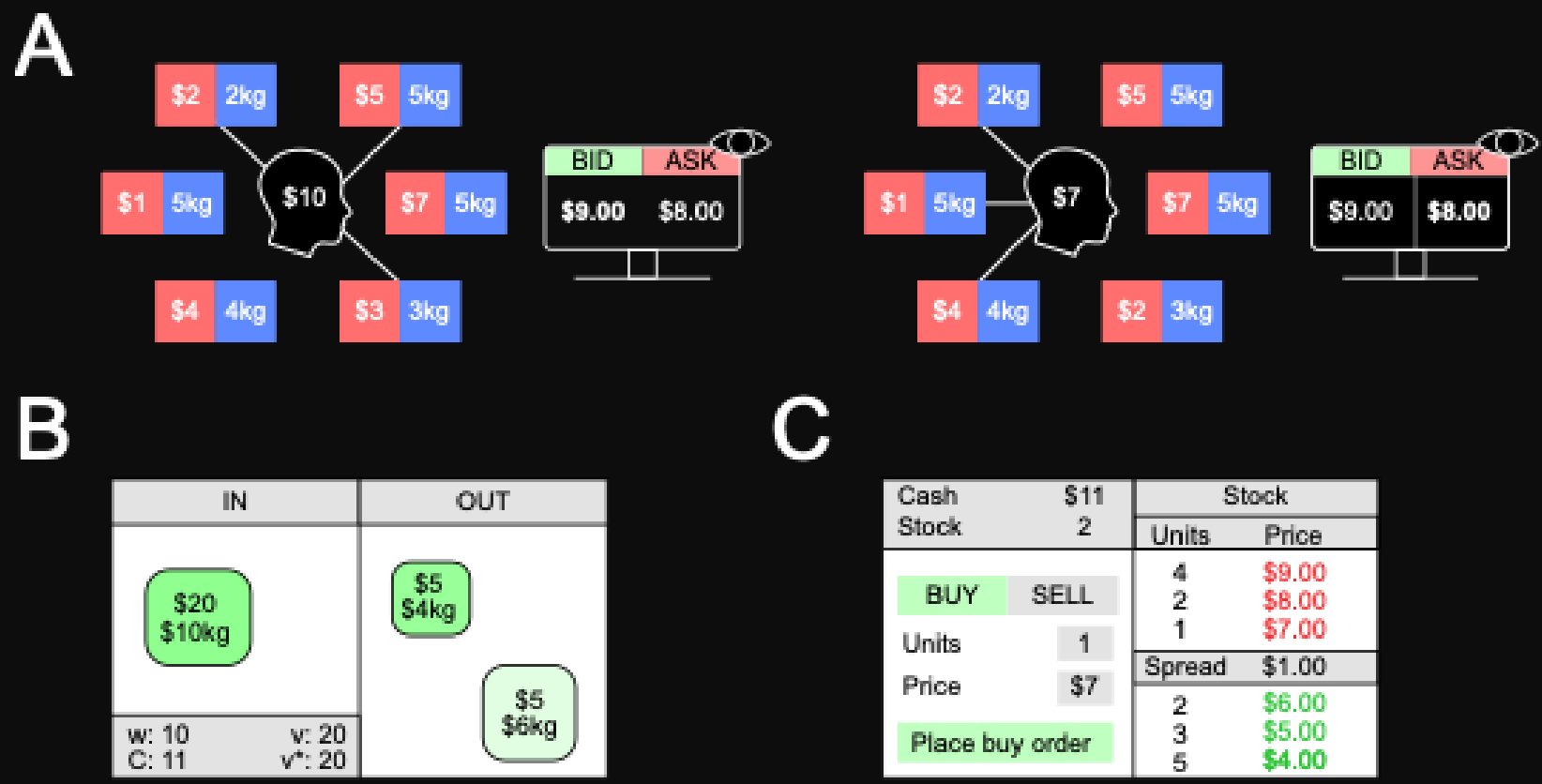
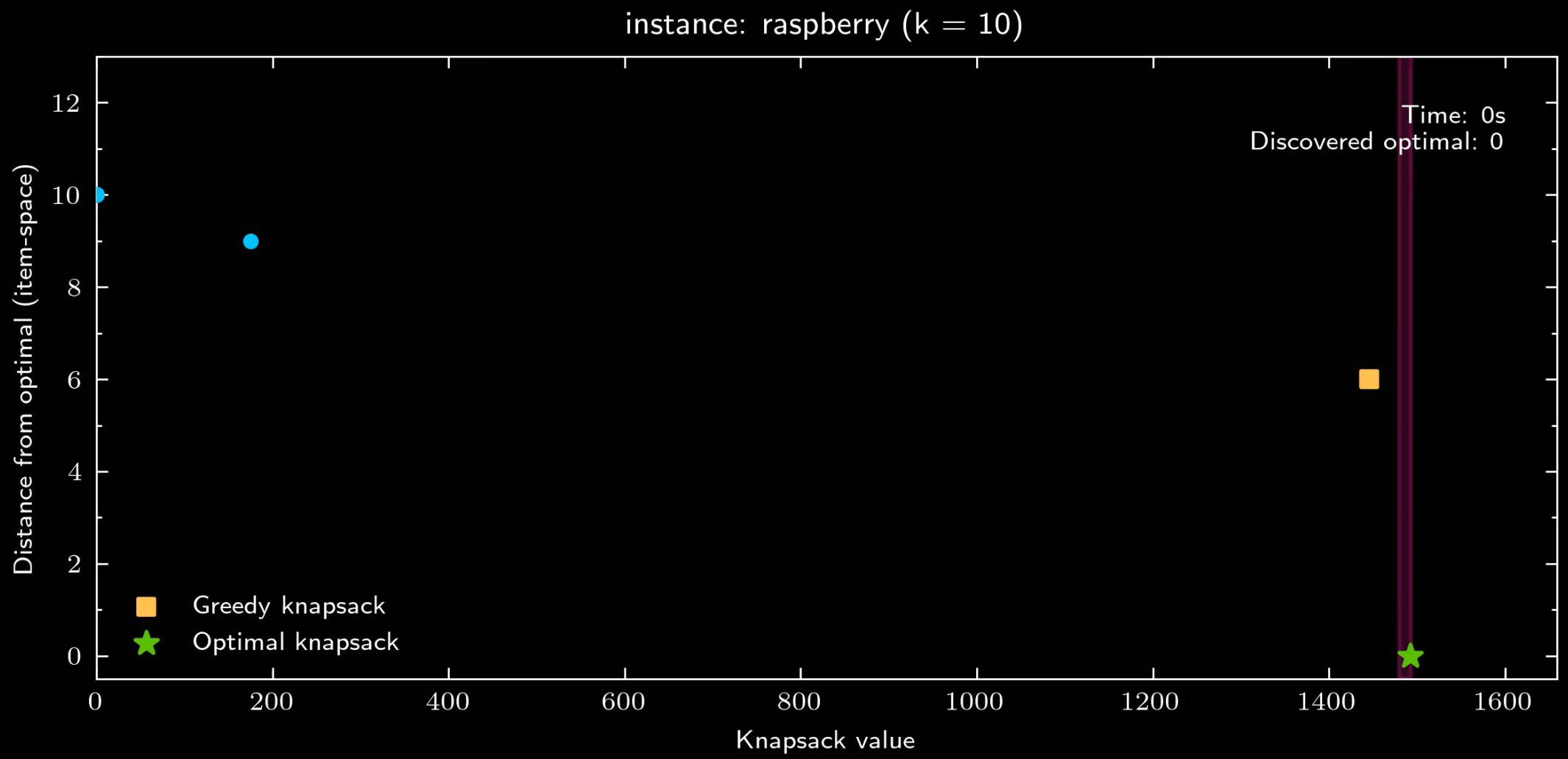


Figure 1: Market experiment. **(A**) Individuals solved KP while observing the price of an asset that paid off the best value found. **(B)** Knapsack interface. **(C)** Trading interface.

Pilot experiment



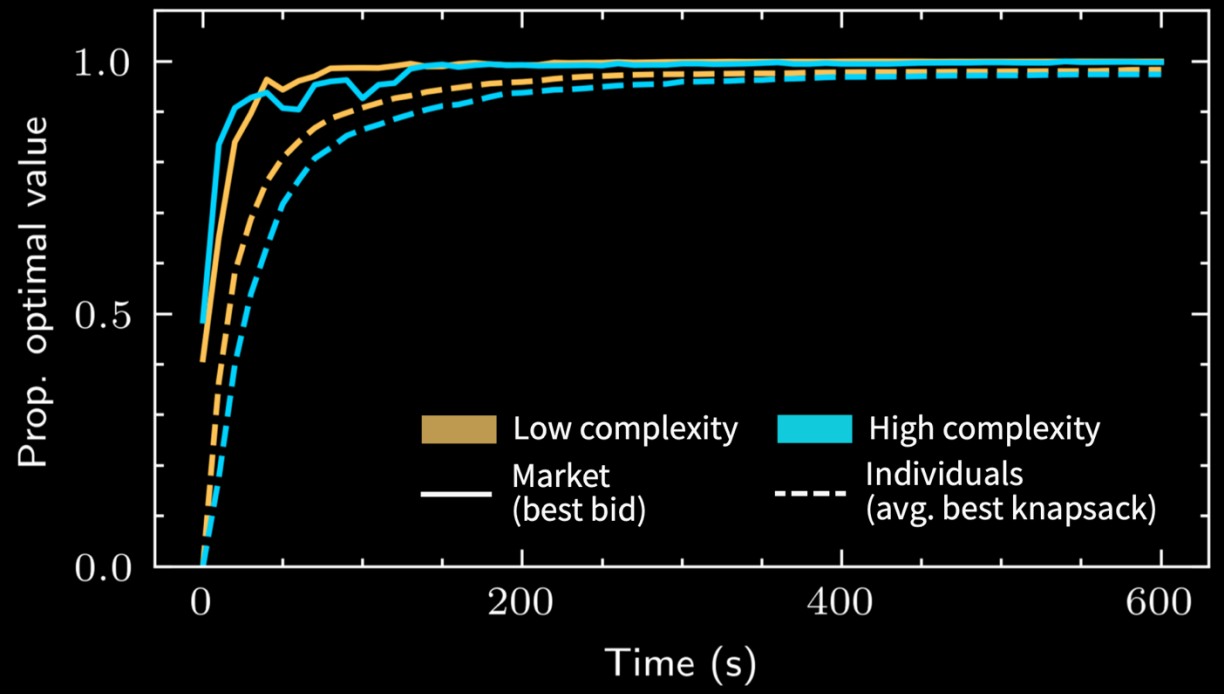
Pilot experiment

Market prices perform better than the average of individuals

Especially so in **harder problems**

Why does this work?

How does performance compare to traditional incentive mechanisms?



Two experiments

1. **Incentives for innovation**
   Do markets motivate greater effort and discovery compared to patents?

2. **Markets as oracles (in progress)**
   How useful is the information embedded in market prices?

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Motivation

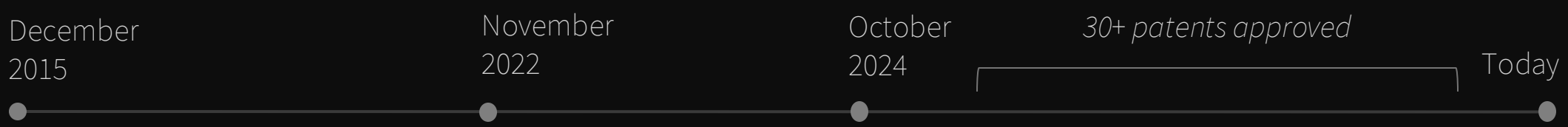
Innovation is socially valuable, but hard to incentivise efficiently

Conventional solution: patents

- Innovators are incentivised to keep innovations to themselves
- Strong incentives, poor information flow

Can markets do better?

A modern case study: OpenAI



”Our goal is to advance digital intelligence in the way that is most likely to benefit humanity as a whole.”

“Researchers will be strongly encouraged to ***publish their work****, whether as papers, blog posts, or code, and our* ***patents (if any) will be shared with the world.”*** [1]

ChatGPT released.

OpenAI abandons not-for-profit structure. Becomes for-profit. [2]

“As we continue to pursue our mission, we . . . pledge to only use our patents defensively, so long as a party does not … engage in activities that harm us or our users”. [3]

[1] openai.com/index/introducing-openai/

[2] openai.com/our-structure/

[3] openai.com/approach-to-patents/

Overview

Participants solve instances of the knapsack problem.

While solving the problems, participants have the option to share their current solutions.

Within-subject design (2 treatments)

Dependent variables
- Quality (# optimal attained)
- Effort (# moves made)
- Information sharing

Patent treatment

The first to submit the highest-valued solution receives a large prize.

All subsequent participants receive nothing.

Market treatment

Participants solve KP while trading in a marketplace.

The traded security yields the average value discovered across all participants by the end of the period

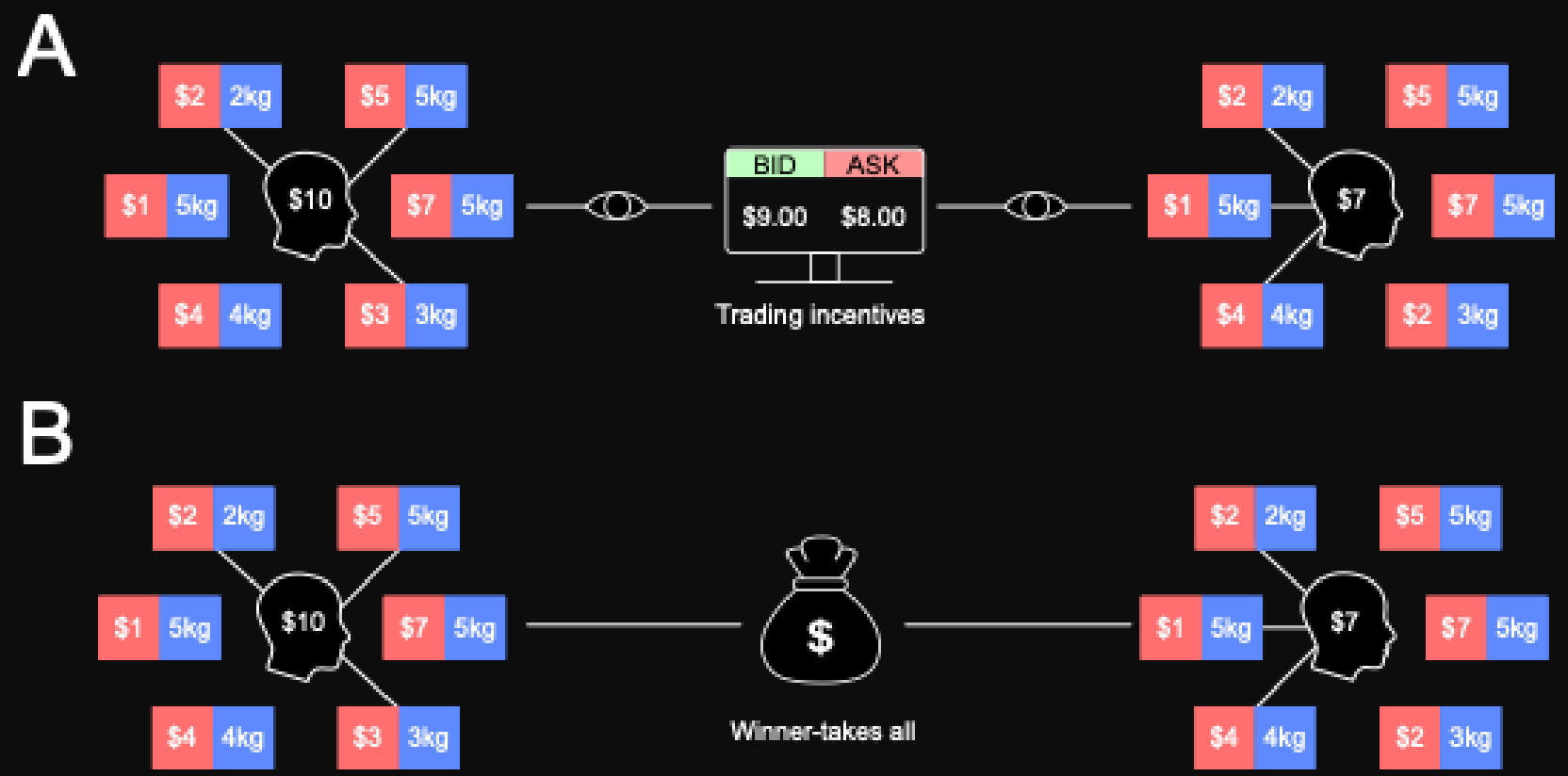


Figure 1: Experimental paradigm, incentives experiment. (A) Market experiment. Solve KP while trading in an online marketplace. The traded security pays the average value achieved across all participants. (B) Patent condition. First person to submit the highest-valued solution takes the prize.

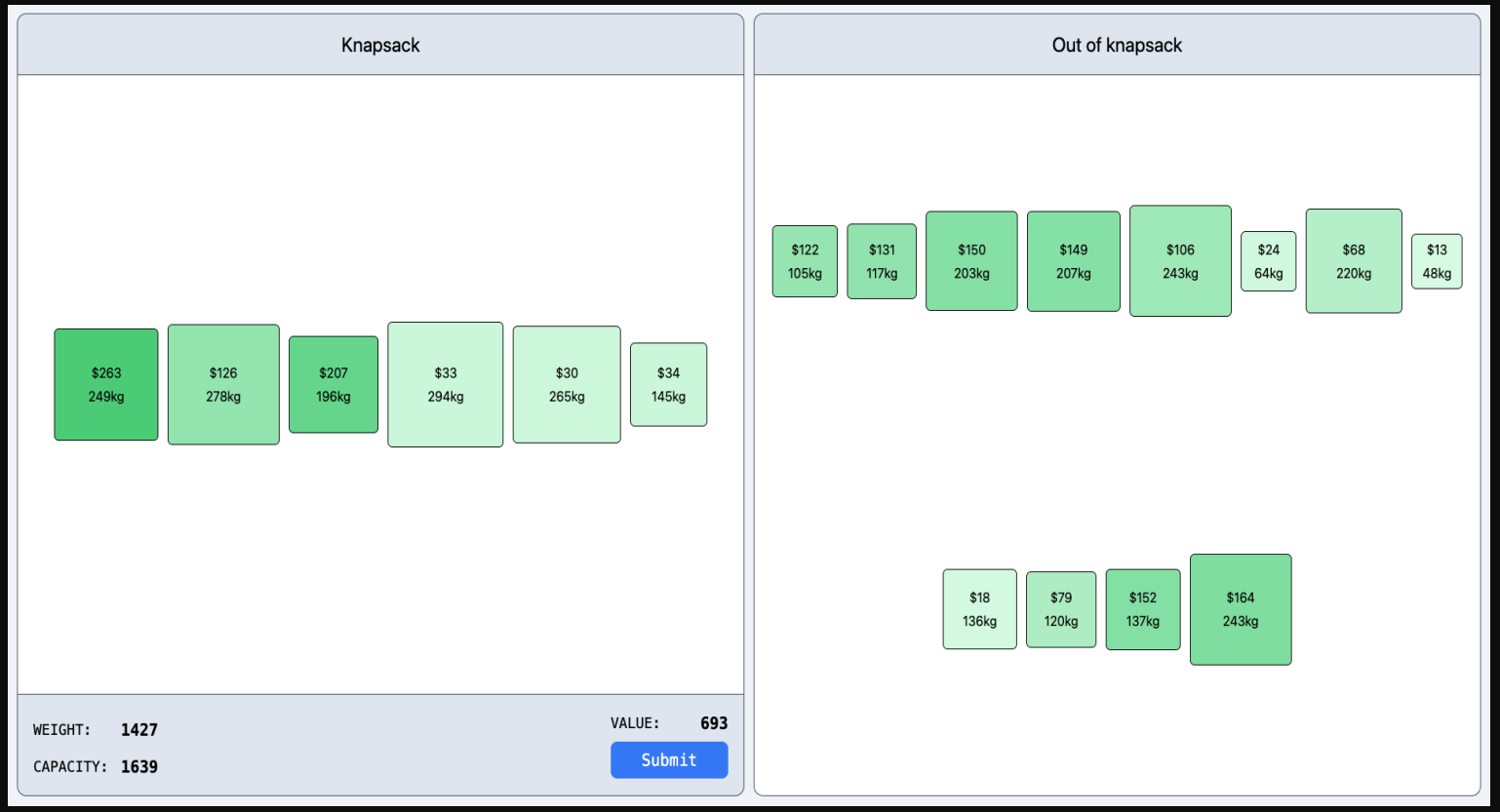


Figure 2: Knapsack interface. Item values (weights) are coded by colour (size).

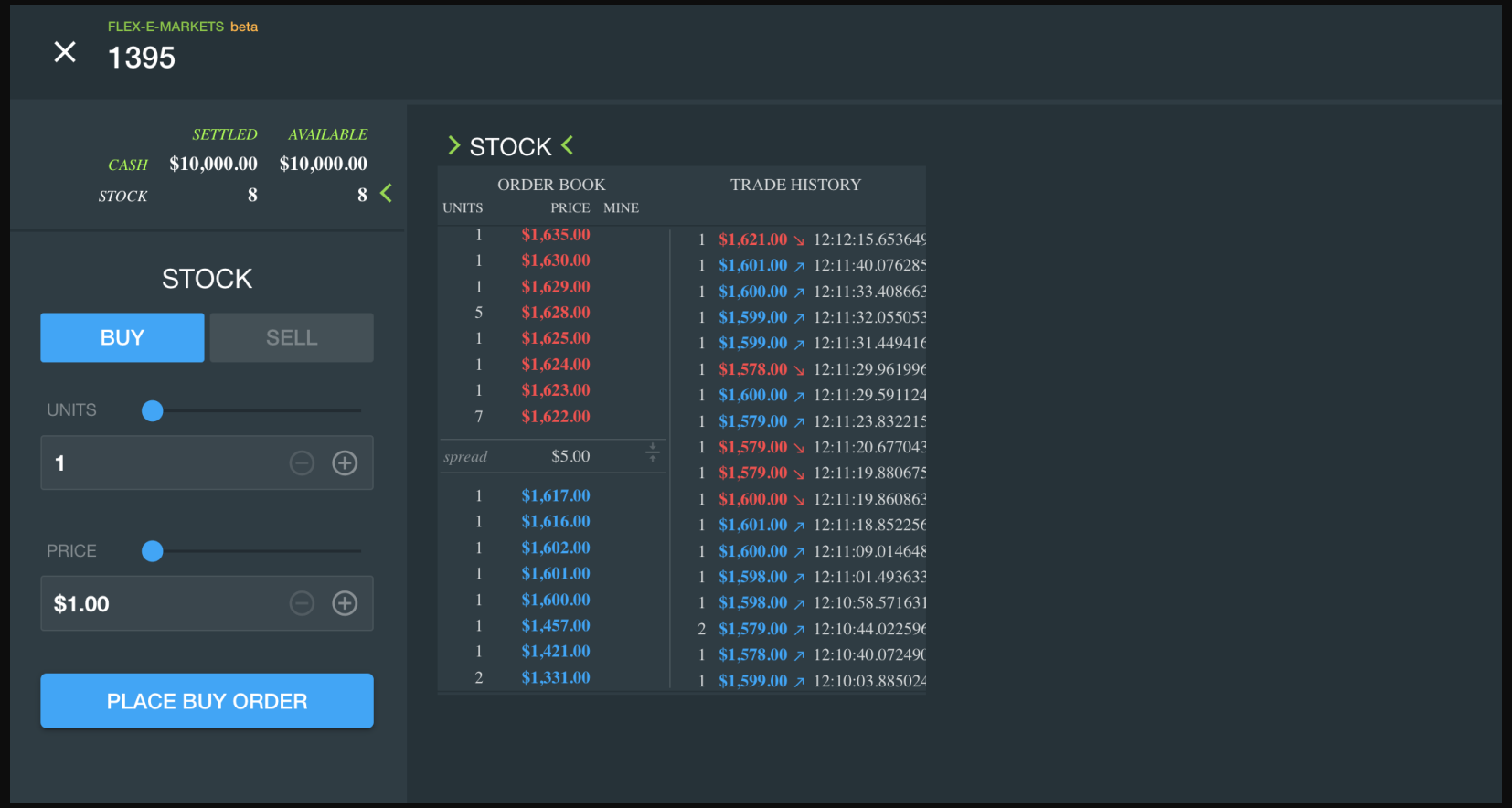


Figure 3: Flex-E-Markets trading interface. Bids (asks) are shown in blue (red).

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Motivation

Extensively studied
- Resource allocation
- Information aggregation

Relatively understudied
- Spreading knowledge of solutions to complex problems

"Knowledge of the kind which by its nature cannot enter into statistics *... the method by which such* ***knowledge can be made as widely available as possible*** *is precisely the problem to which we have to find an answer"*

The Use of Knowledge in Society
F.A. Hayek, 1945

Overview

Participants solve instances of the knapsack problem.

While solving the problems, participants receive various levels of information about the optimal solution.

Within-subject design (3 treatments)

Dependent variables
- Quality (# optimal attained)
- Effort (# moves made)

Control (no information)

Participants solve KP on their own, without receiving any additional information.

Optimal signal

Participants solve KP after being told the true optimal value of the instance.

Market signal

Participants solve KP while trading. The traded security yields the maximum value discovered across all participants by the end of the period

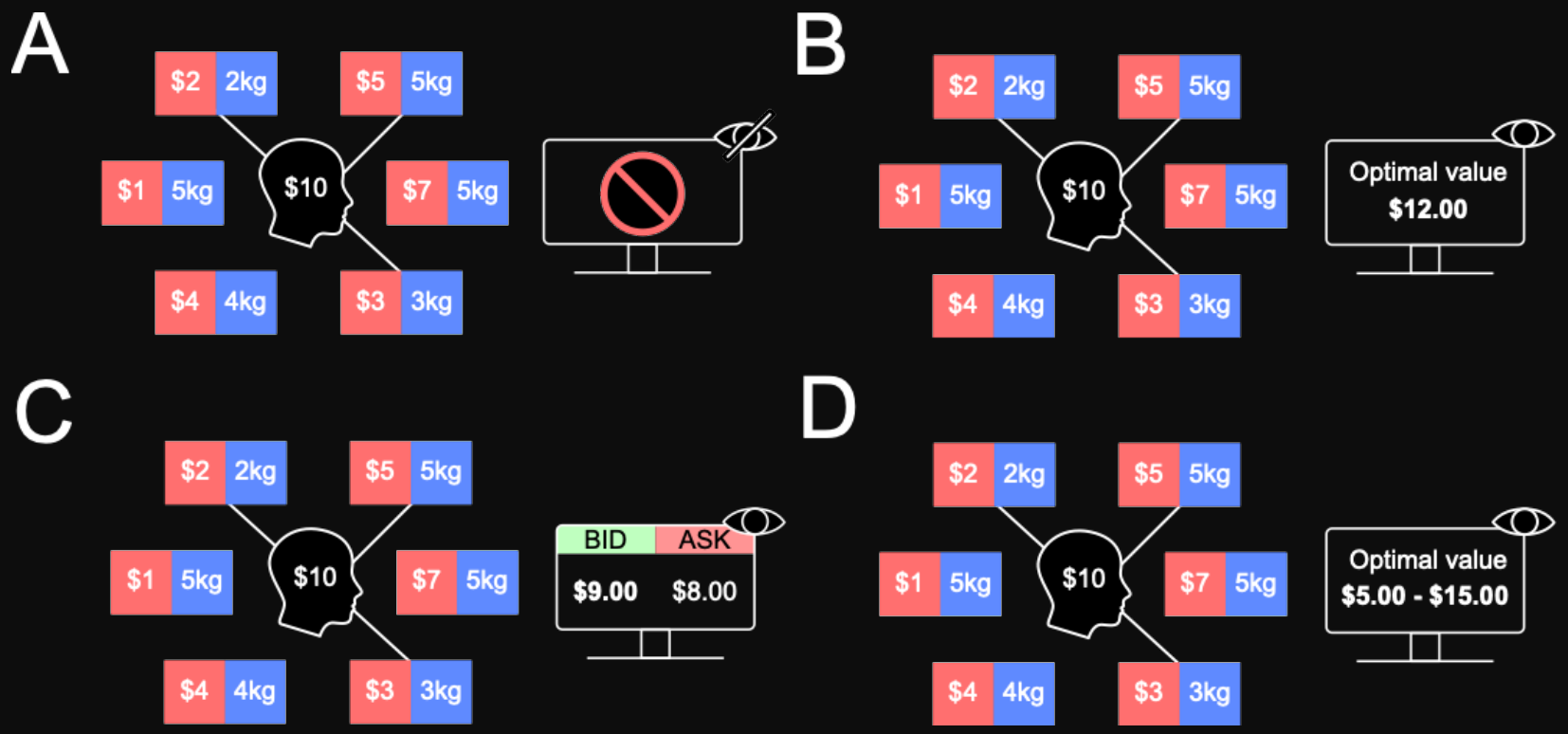

Figure 4: Experimental paradigm, price signals experiment. (A) Control condition. Solved the KP independently. (B) Information signal condition. Solved the KP after being told the optimal value. (C) Market experiment. Solved KP while trading in an online marketplace. The traded security promises a liquidating dividend equal to the best value discovered by any participant. (D) Gradual signal condition. Precision of signal increases over time.

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But collectives can approximate solutions by dividing search effort

How do we incentivise individuals to communicate and **share knowledge**?

How useful is the collective knowledge embedded in market prices?

Incentives for innovation

Do markets motivate greater effort and discovery compared to patents?

Markets as oracles

How useful is the information embedded in market prices?

Summary

		Incentives					
		Individual (first to optimal)	Individual (first to best found)	Individual (value-based)	Market (average)	Market (optimal)	Market (best found)
Signal	No-signal	Meloso et al. (2009)	Andrabi et al. (2025)	Andrabi et al. (2025)			
	Perfect			Andrabi et al. (2025)			
	Market			Andrabi et al. (2025)	Andrabi et al. (2025)	Meloso et al. (2009)	Andrabi et al. (2025)*

* Data partially collected

Experiment 1
Experiment 2
Pilot

Thank you

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