

Impact of Rankings and Personalized Recommendations in Marketplaces



Akshit Kumar

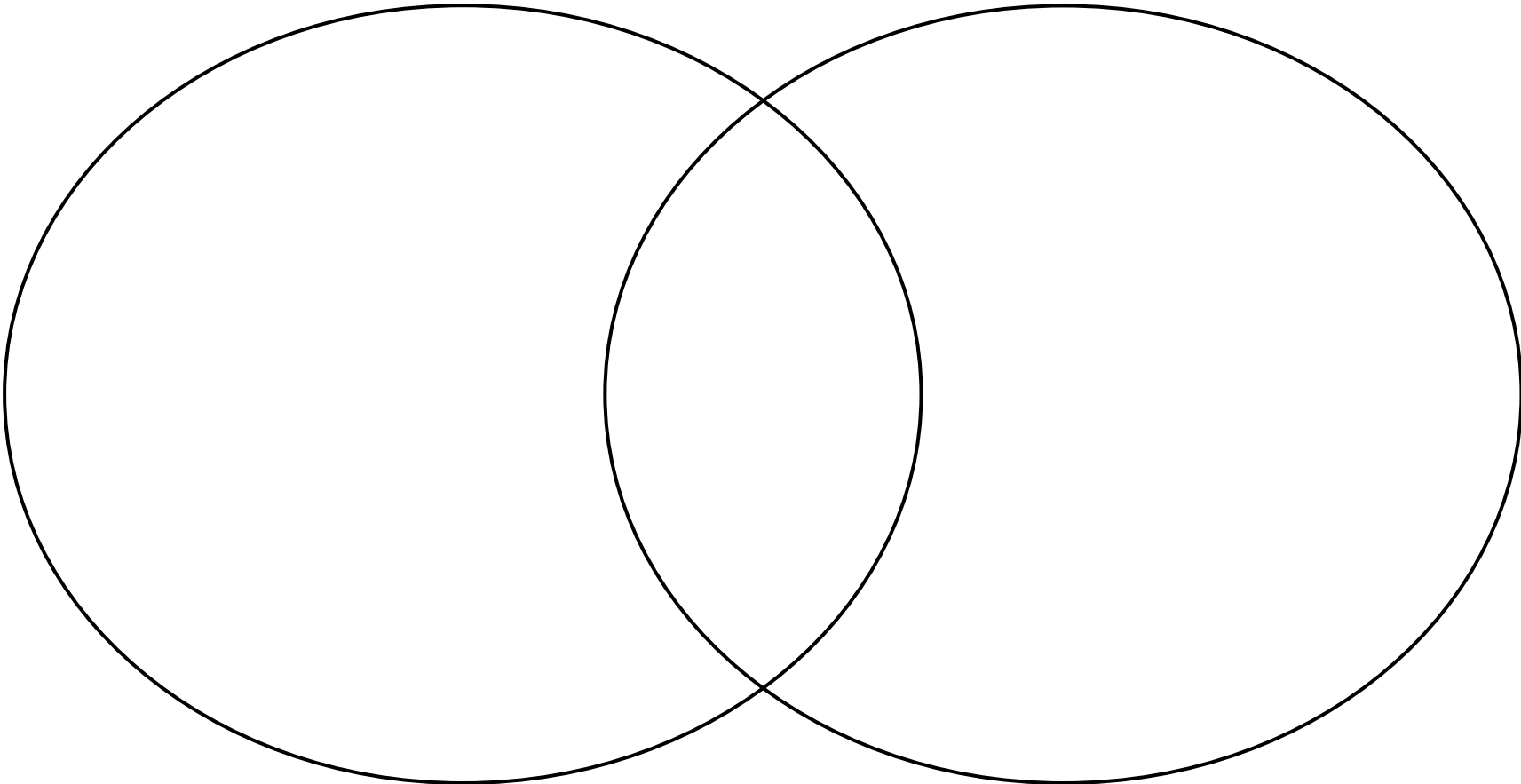
Joint work with Omar Besbes and Yash Kanoria

Core Research: Platform Operations

Core Research: Platform Operations

Allocation

Recommendations



Core Research: Platform Operations

Allocation

Recommendations



Feature-Based Dynamic Matching

Chen, Kanoria, K, Zhang

[EC'23, Major Revision in OR]

Marketplaces

Online Matching

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Dynamic Resource Allocation:
Algorithmic Design Principles &
Spectrum of Achievable Performances

Besbes, Kanoria, K

[EC'22, Forthcoming in OR]

Network Revenue Management

Order Fulfillment

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The Fault in Our Recommendations:
On the Perils of Optimizing the
Measurable

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[RecSys'24]

Recommendation Systems

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Recommendation Systems

Platform Design

Develop models and methods to optimize platform operations

In a Nutshell

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 - **Public Rankings:** Provide an overall assessment of the options
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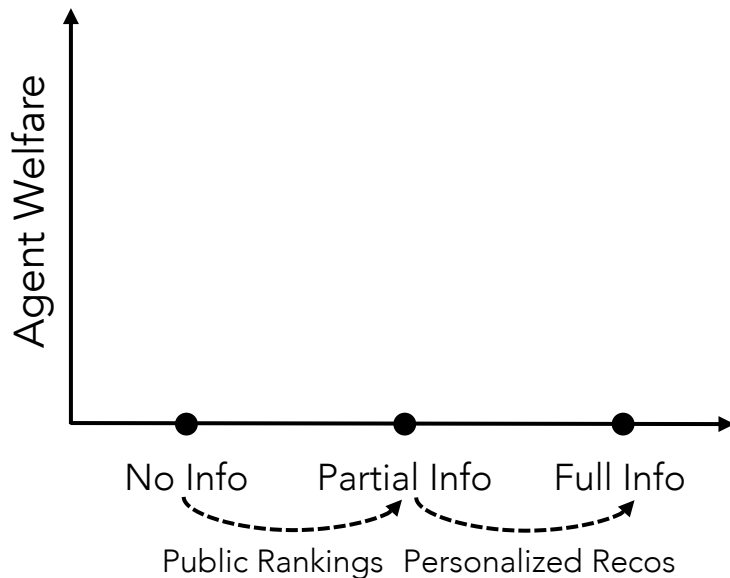
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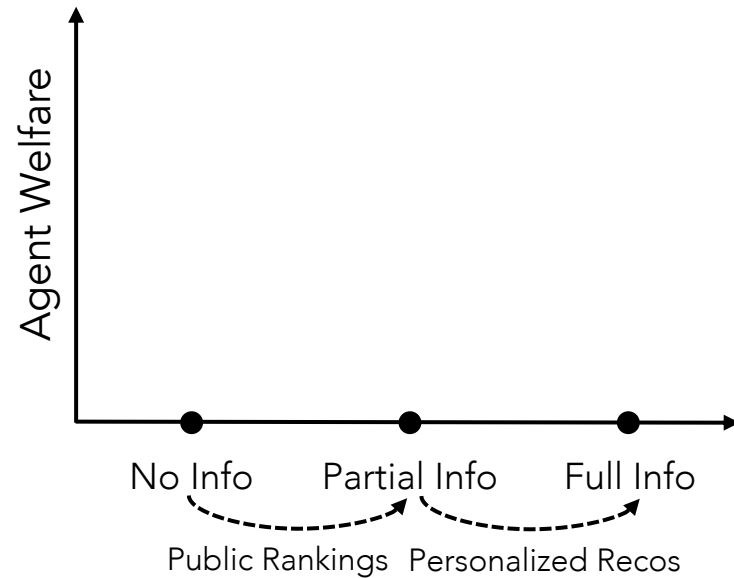
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With Supply Constraints



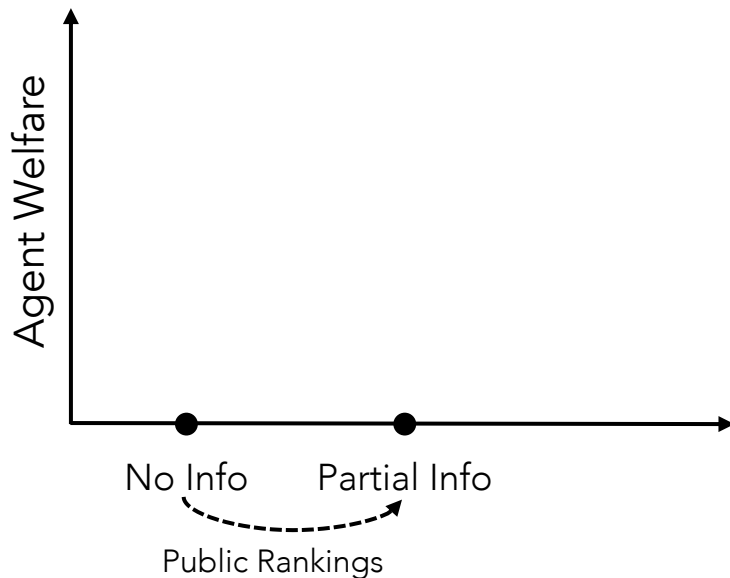
Without Supply Constraints



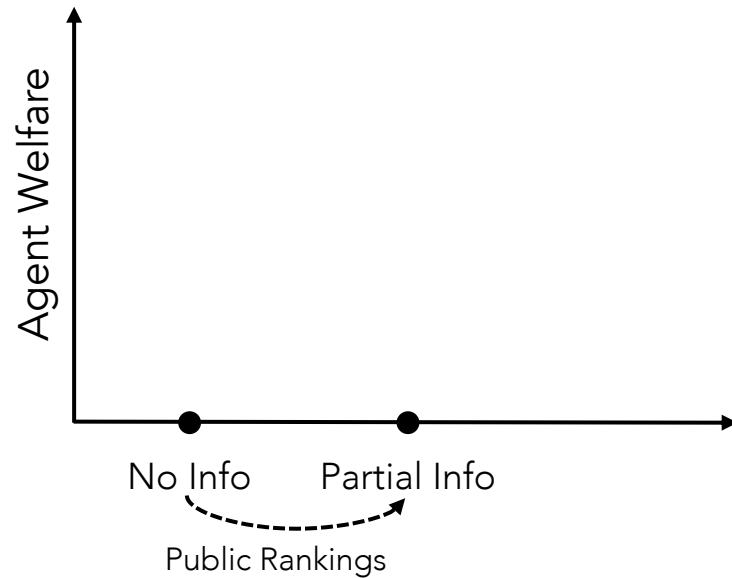
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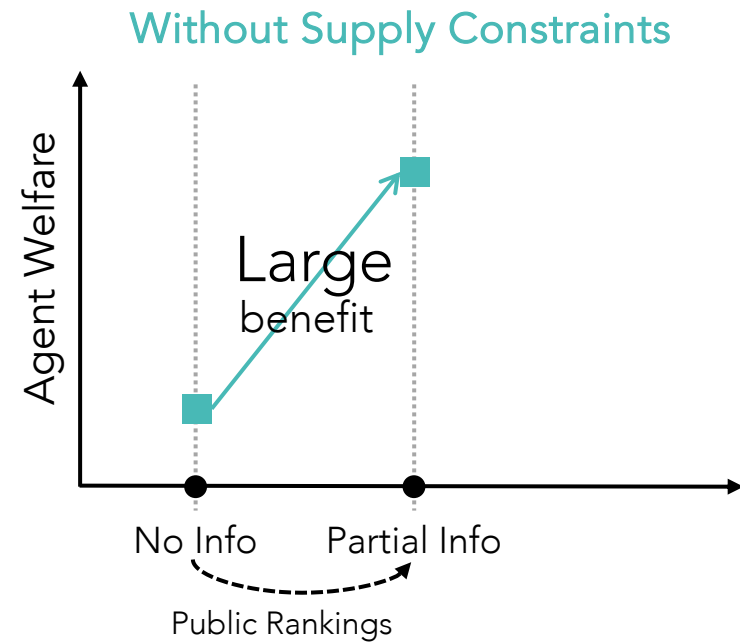
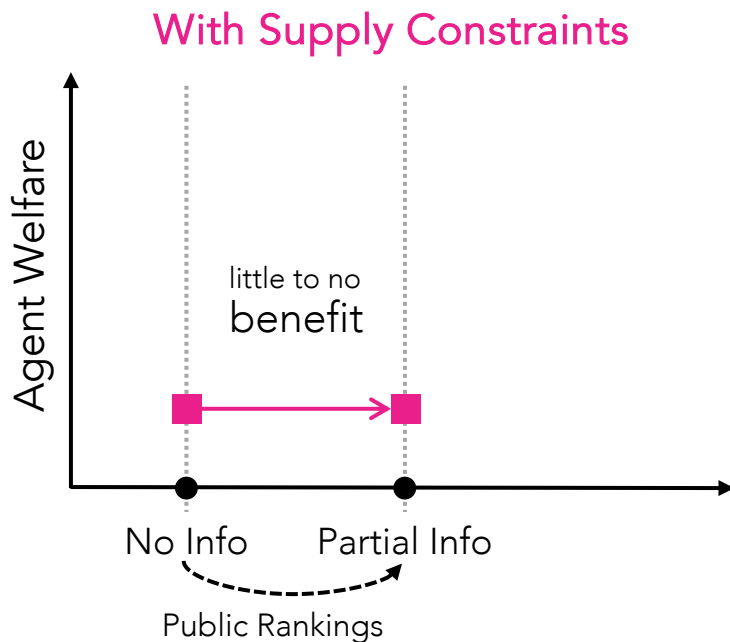


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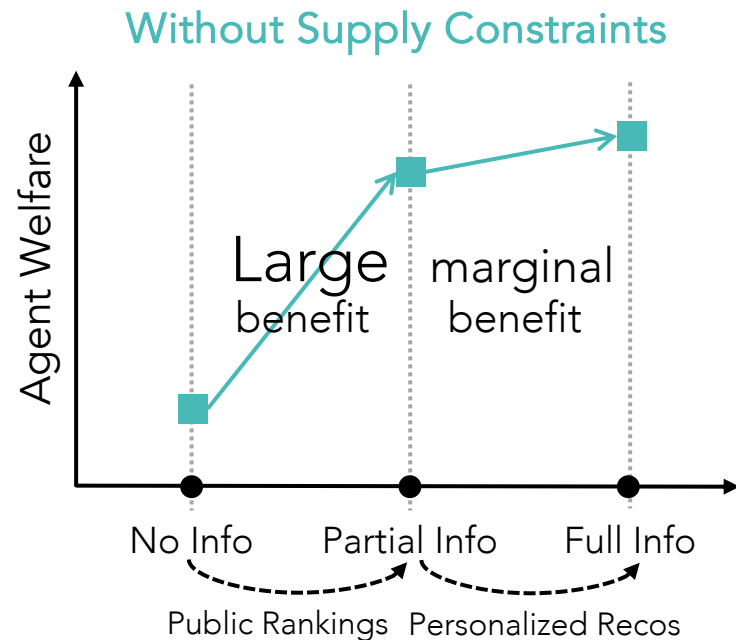
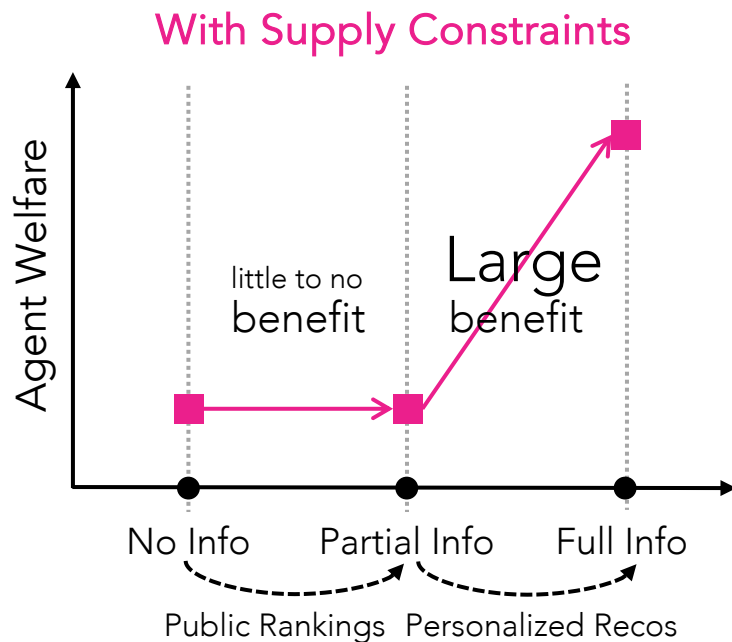
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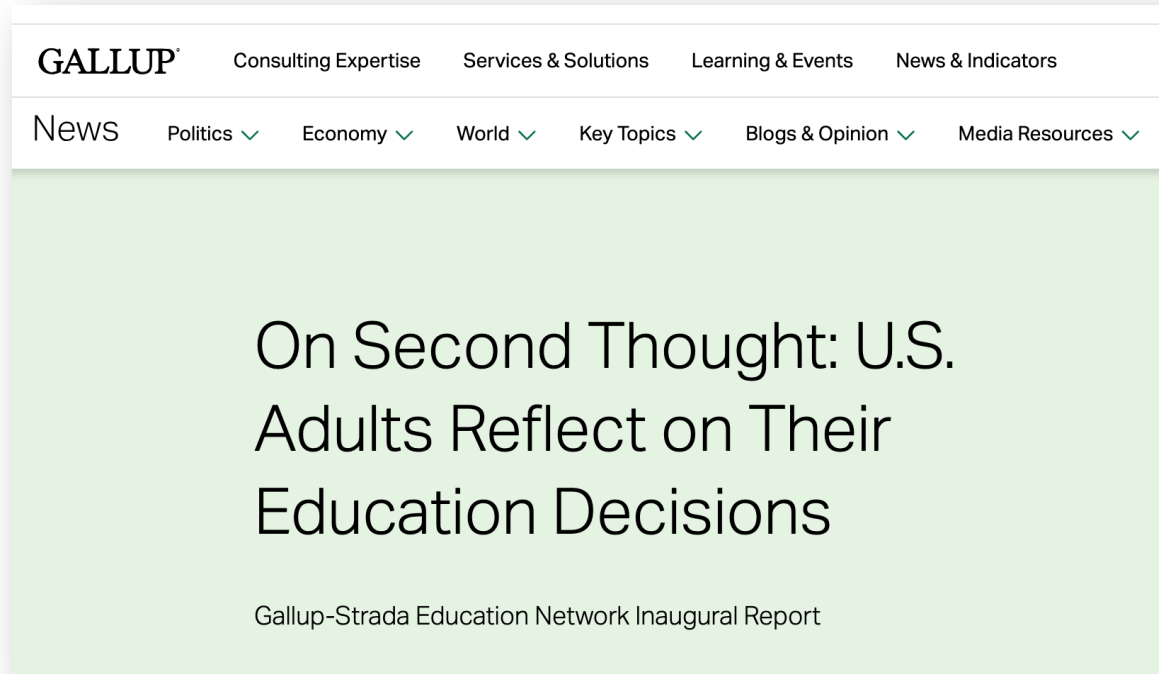
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We have ill-formed preferences

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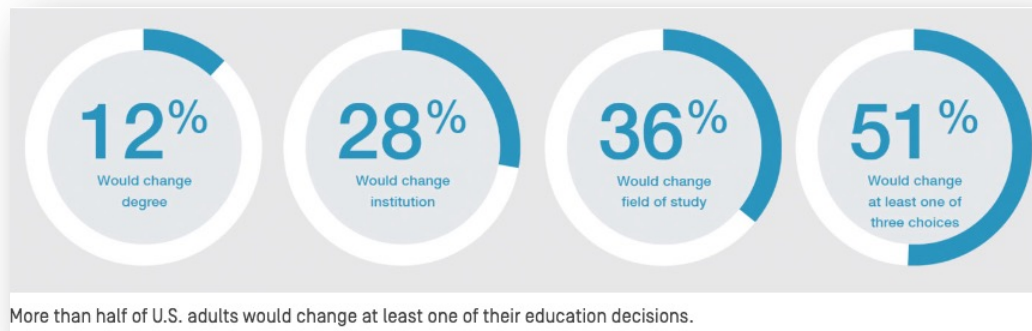
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GALLUP Consulting Expertise Services & Solutions Learning & Events News & Indicators

News Politics ▾ Economy ▾ World ▾ Key Topics ▾ Blogs & Opinion ▾ Media Resources ▾

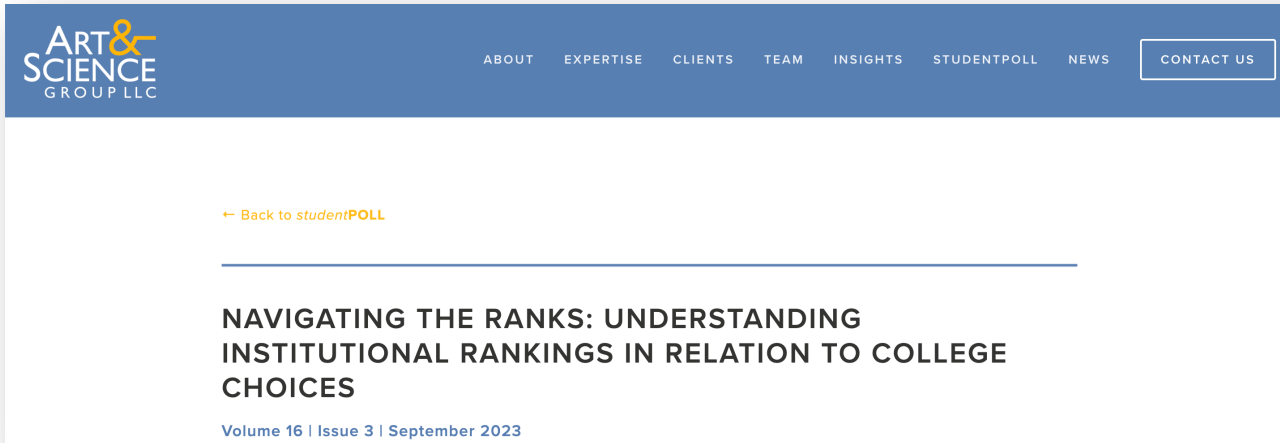
On Second Thought: U.S. Adults Reflect on Their Education Decisions

Gallup-Strada Education Network Inaugural Report



We use rankings to decide colleges

We use rankings to decide colleges



ART & SCIENCE GROUP LLC

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NAVIGATING THE RANKS: UNDERSTANDING INSTITUTIONAL RANKINGS IN RELATION TO COLLEGE CHOICES

Volume 16 | Issue 3 | September 2023

The image shows a screenshot of a website. At the top left is the logo for 'ART & SCIENCE GROUP LLC'. To the right of the logo is a navigation menu with the following items: 'ABOUT', 'EXPERTISE', 'CLIENTS', 'TEAM', 'INSIGHTS', 'STUDENTPOLL', 'NEWS', and 'CONTACT US'. The 'CONTACT US' item is enclosed in a white rectangular button. Below the navigation menu, there is a link that says '← Back to studentPOLL'. A horizontal line is positioned below the link. Underneath the line is the main title of the article: 'NAVIGATING THE RANKS: UNDERSTANDING INSTITUTIONAL RANKINGS IN RELATION TO COLLEGE CHOICES'. At the bottom of the article preview, it says 'Volume 16 | Issue 3 | September 2023'.

We use rankings to decide colleges

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Key Findings

58%
of high school seniors who are investigating colleges have **actively considered** rankings

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NATIONAL UNIVERSITIES

Schools in the National Universities category offer a full range of undergraduate majors, plus master's and Ph.D. programs.



Princeton University
#1 in National Universities



Harvard University
#3 in National Universities (tie)



Massachusetts Institute of Technology
#2 in National Universities



Stanford University
#3 in National Universities (tie)

[SEE FULL RANKING LIST »](#)



We use rankings to decide movies



★ 9.3 (2.9M) ☆ Rate

1. The Shawshank Redemption

1994 2h 22m

Watch options



★ 9.2 (2M) ☆ Rate

2. The Godfather

1972 2h 55m

Watch options



★ 9.0 (2.9M) ☆ Rate

3. The Dark Knight

2008 2h 32m

Watch options

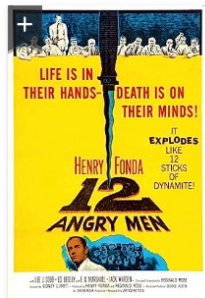


★ 9.0 (1.4M) ☆ Rate

4. The Godfather Part II

1974 3h 22m

Watch options



★ 9.0 (883K) ☆ Rate

5. 12 Angry Men

1957 1h 36m



★ 9.0 (1.5M) ☆ Rate

6. Schindler's List

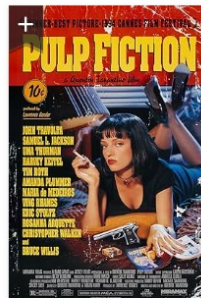
1993 2h 27m



★ 9.0 (2M) ☆ Rate

7. The Lord of the Rings: The Return of...

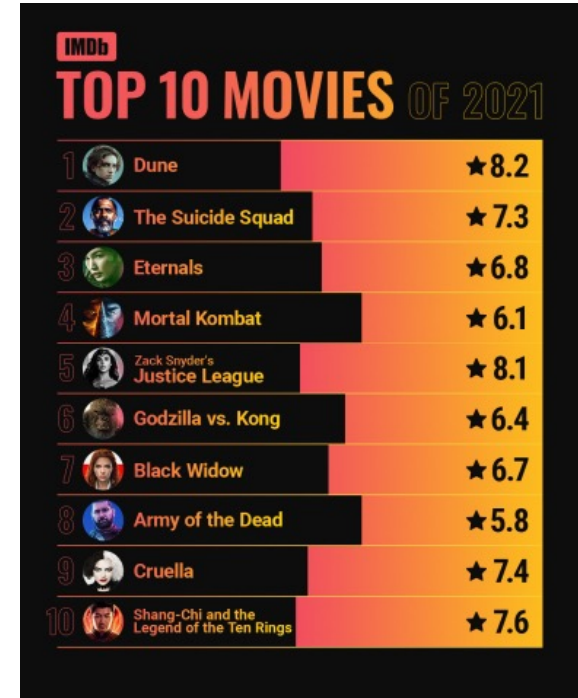
2003 2h 58m



★ 8.9 (2.3M) ☆ Rate

8. Pulp Fiction

1994 1h 54m



But rankings aren't personalized...

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Many platforms (aim to) provide personalized recos to each user

NETFLIX

 **YouTube**



Instagram

facebook



Spotify[®]

But rankings aren't personalized...

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There is **no supply-side constraints** on these platforms

Personalized Recos underexplored
in supply constrained settings

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One important setting is **Centralized College Admissions**

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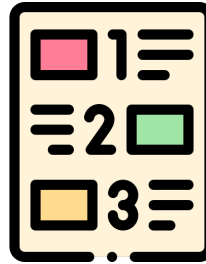
Students take one/multiple
exams

Personalized Recos underexplored in supply constrained settings

One important setting is **Centralized College Admissions**



Students take one/multiple exams



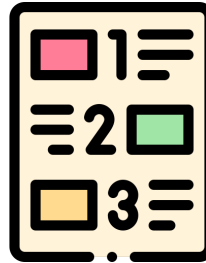
Students get a priority order based on the exam performance

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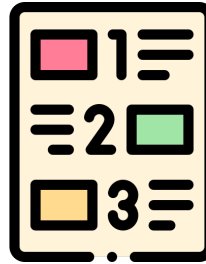
Students are *sequentially* invited to choose their college

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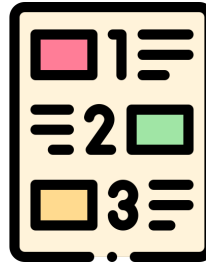
Students are making these choices with **partial information** such as rankings

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One important setting is **Centralized College Admissions**



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Students get a priority order based on the exam performance



Students are *sequentially* invited to choose their college



Students are making these choices with **partial information** such as rankings

This is also applicable* to online platforms like **AirBnB, Upwork**, etc.

*the priority order is some random order

Personal Recommendation Tools

Personal Recommendation Tools

CORE, The Academic Explorer

Course Recommendation Engine

Enter your name:

Select your gender:

Male



Provide your preference order for colleges and courses:

Select College 1:

Select College 2:

Select College 3:

Select College 4:

Recommender Systems for
College Recommendations

Personal Recommendation Tools

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Recommender Systems for
College Recommendations

Electives Chatbot

This is based on the starter kit with ReactJS + NextJS + TypeScript. You can [download the source code](#) for this Starter Kit from GitHub.

Contact Us



I am a chat assistant to help you navigate classes offered at CBS. How can I help you?

Enter your message...

Send

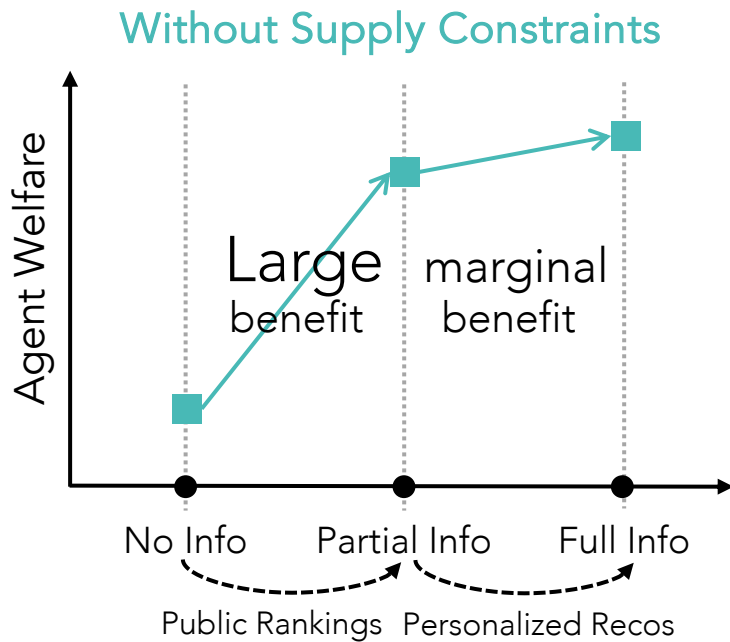
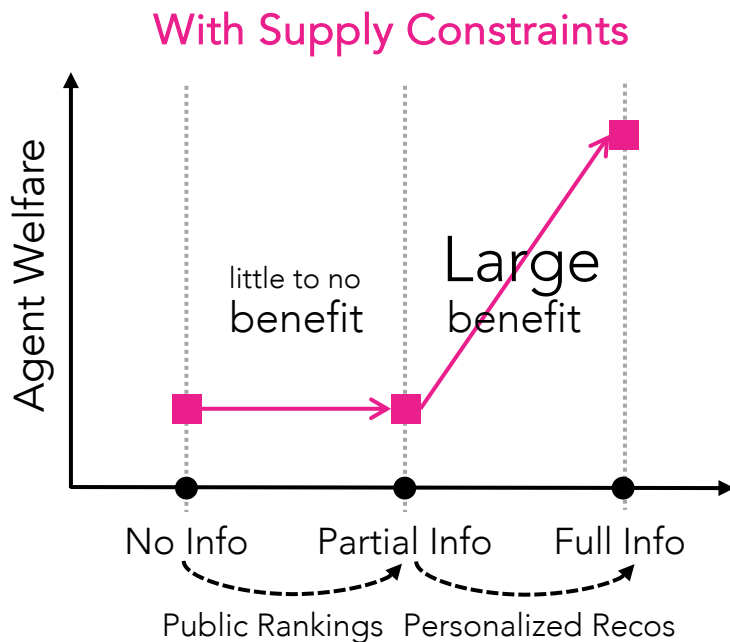
Chatbots for Course
Recommendations

Research Problem

How much value do different information levers - rankings & personalized recommendations - provide **with** & **without** supply side constraints?

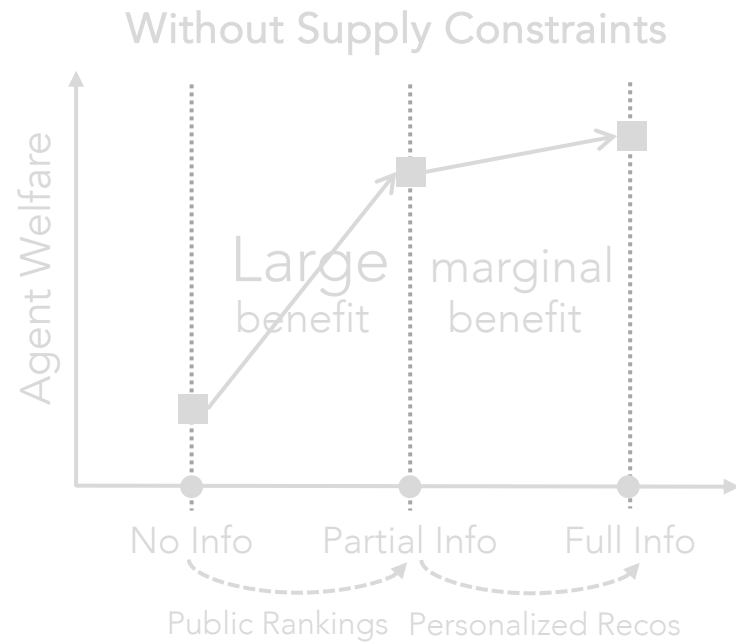
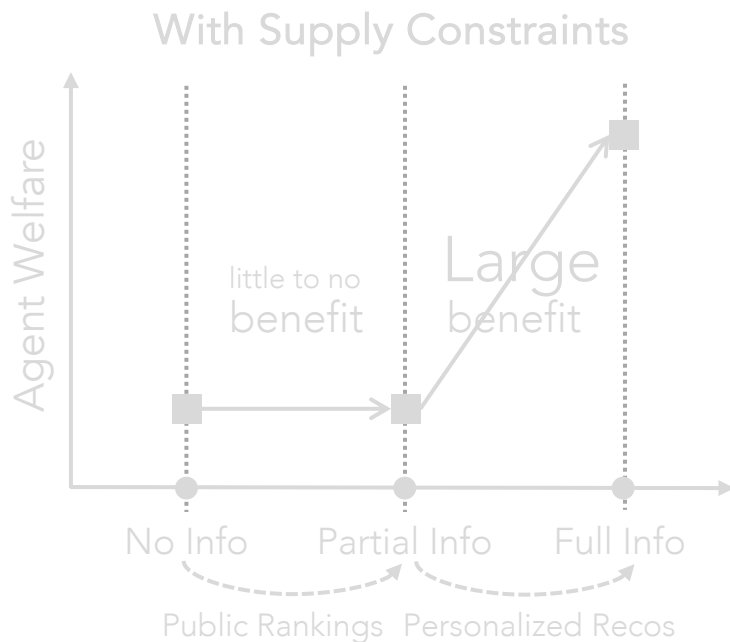
Our solution

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Model

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Model

Model

- n agents and n items



agents

items

Model

- n agents and n items
- Agent Utility
 - $U(a, i) = \rho \cdot q(i) + (1 - \rho) \cdot \varphi(a, i)$



agents

items

Model

- n agents and n items
- Agent Utility
 - $U(a, i) = \rho \cdot q(i) + (1 - \rho) \cdot \varphi(a, i)$
 - $q(i)$: Common term depends only on the item



$q(1)$



$q(2)$



$q(3)$



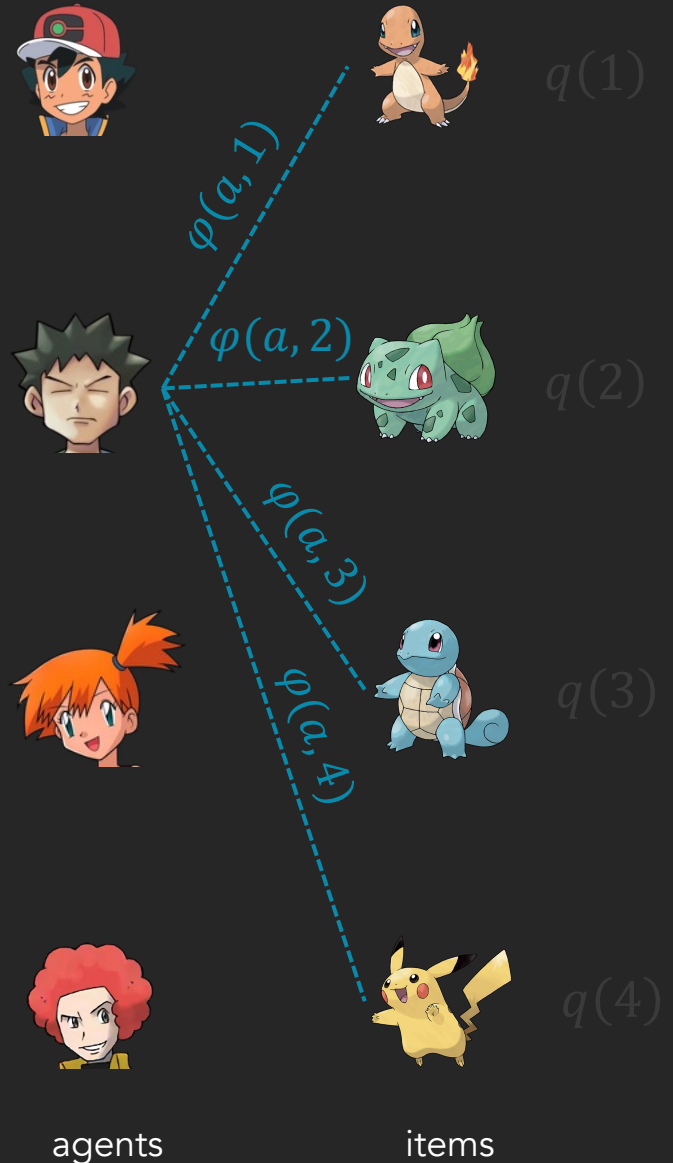
$q(4)$

agents

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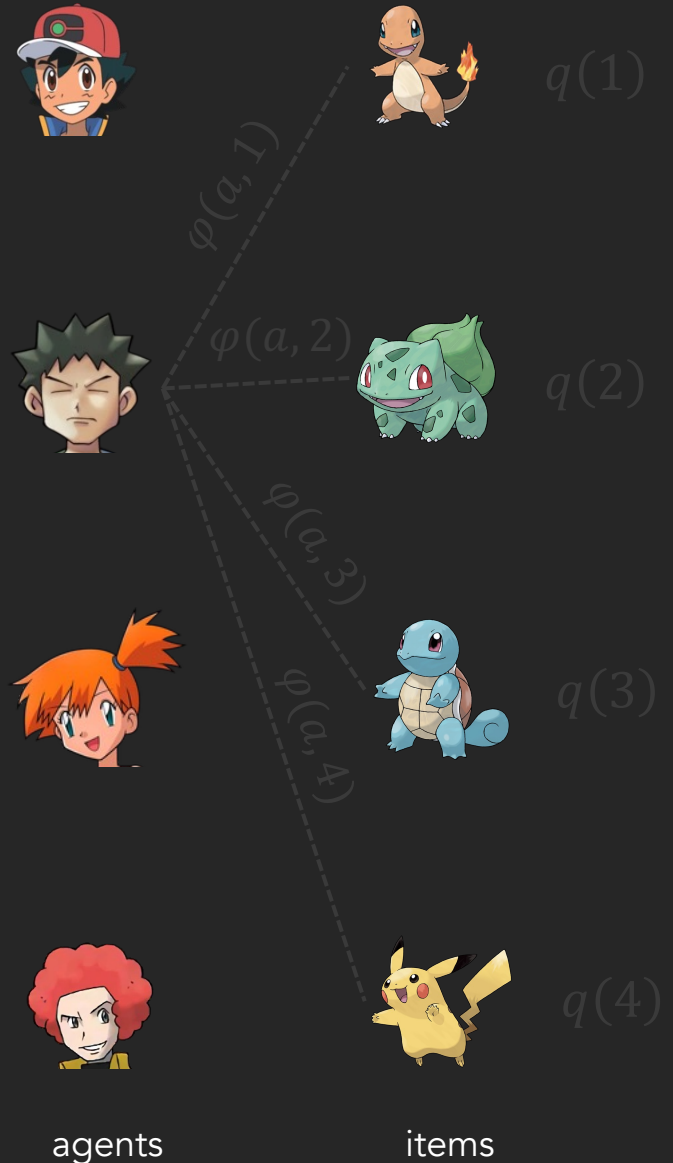
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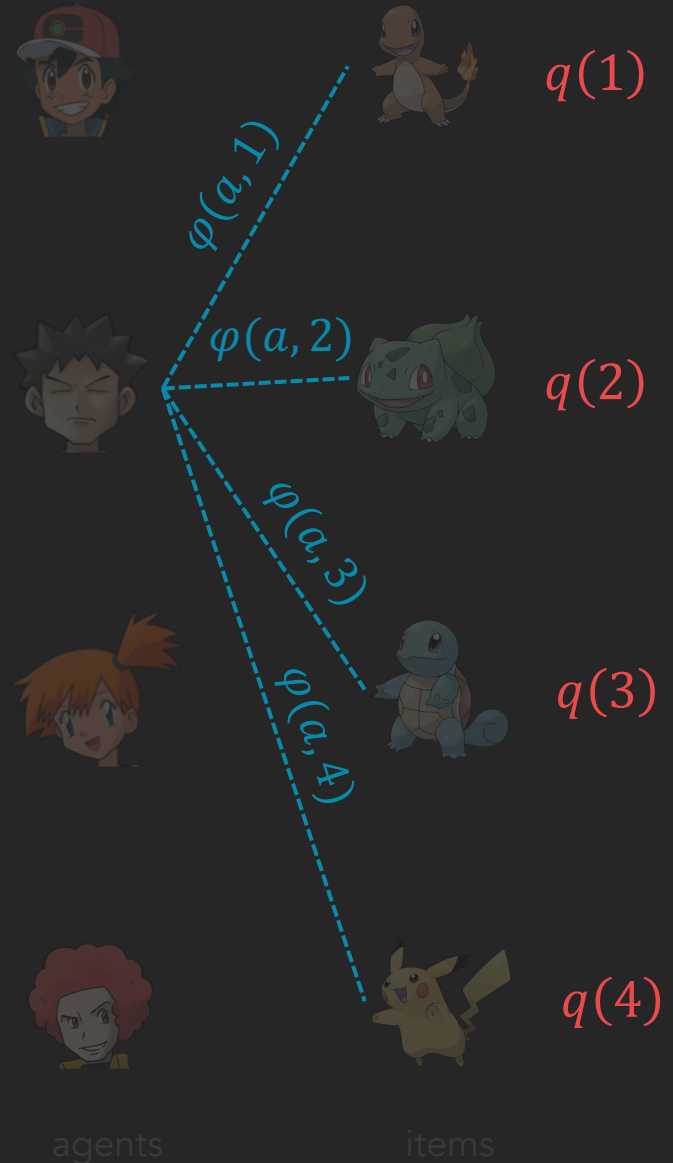
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 - ρ : level of heterogeneity in utility
- Assumptions
 - q and φ are independent of each other
 - $q(i)$ drawn i.i.d from P_q
 - $\varphi(a, i)$ drawn i.i.d from P_φ



Model

- Sequential selection of items
 - Agents are **ordered** according to some priority score and have **unit demand**
 - Agents arrive sequentially and select their preferred item from **remaining set of items**



agents

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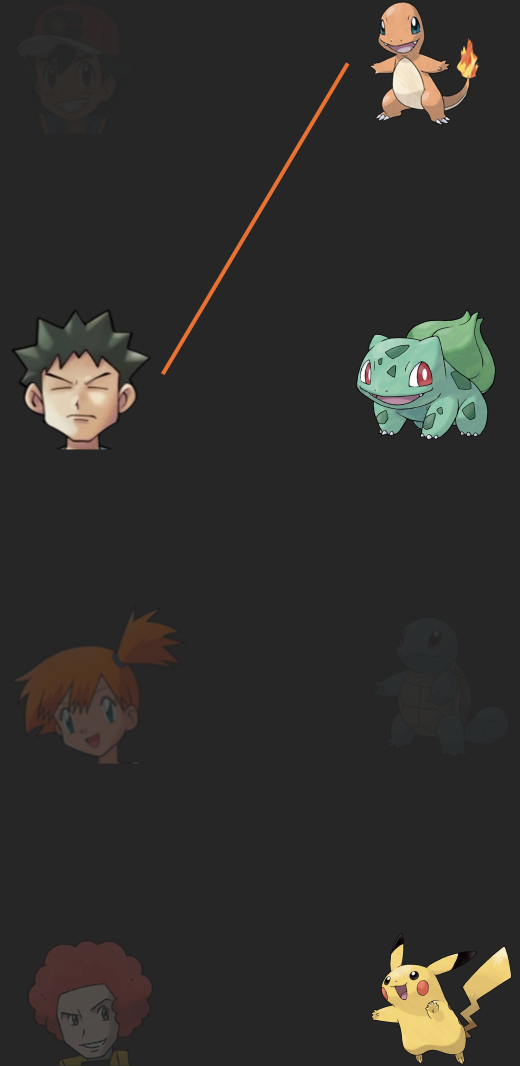


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- **Capacitated Supply Setting**
 - Each item has unit capacity
 - One-to-one match between agents & items

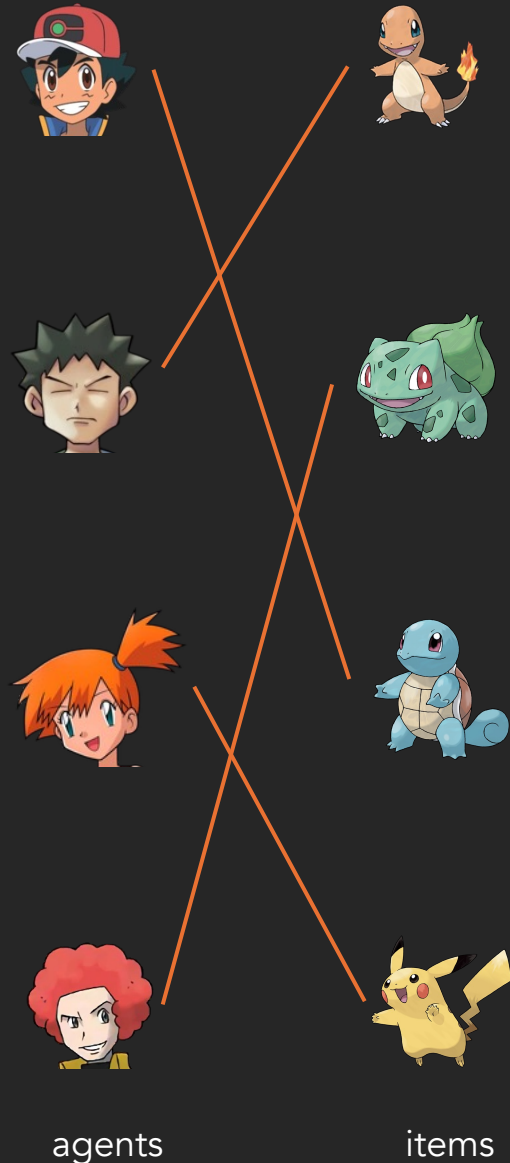


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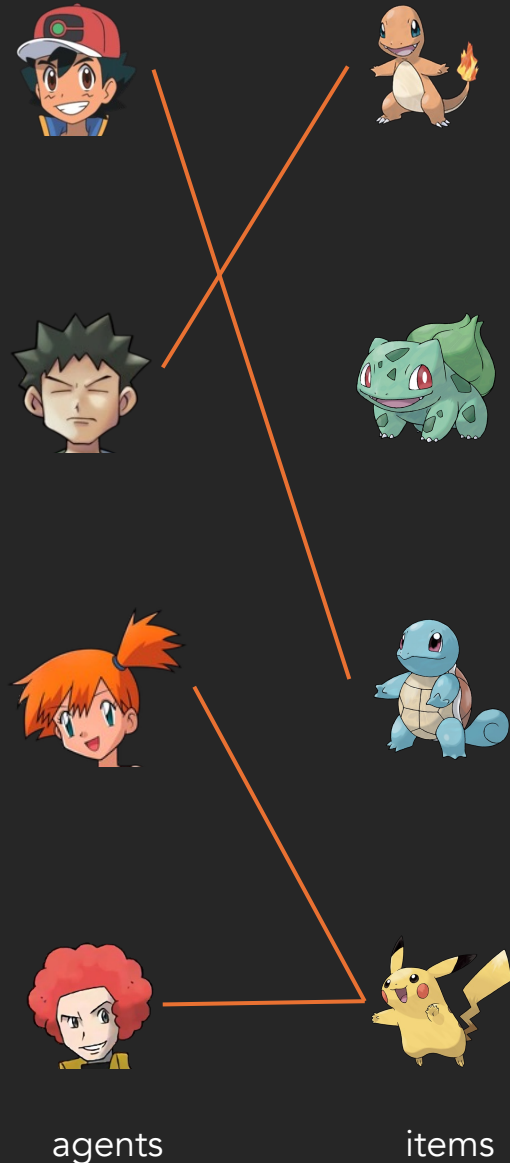


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- Key Measure of Interest
 - **Agent Welfare**: Expected average utility across agents

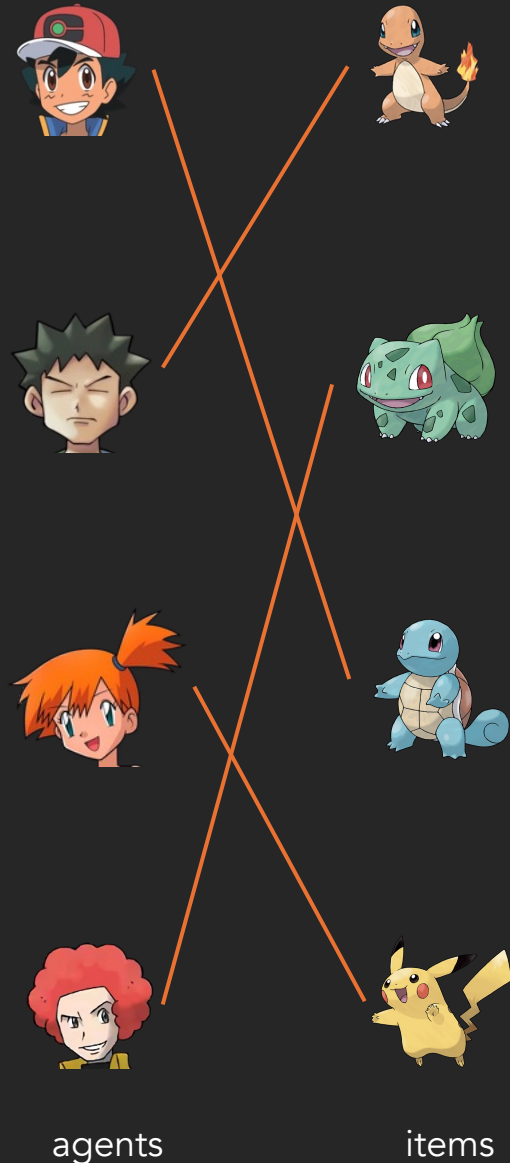


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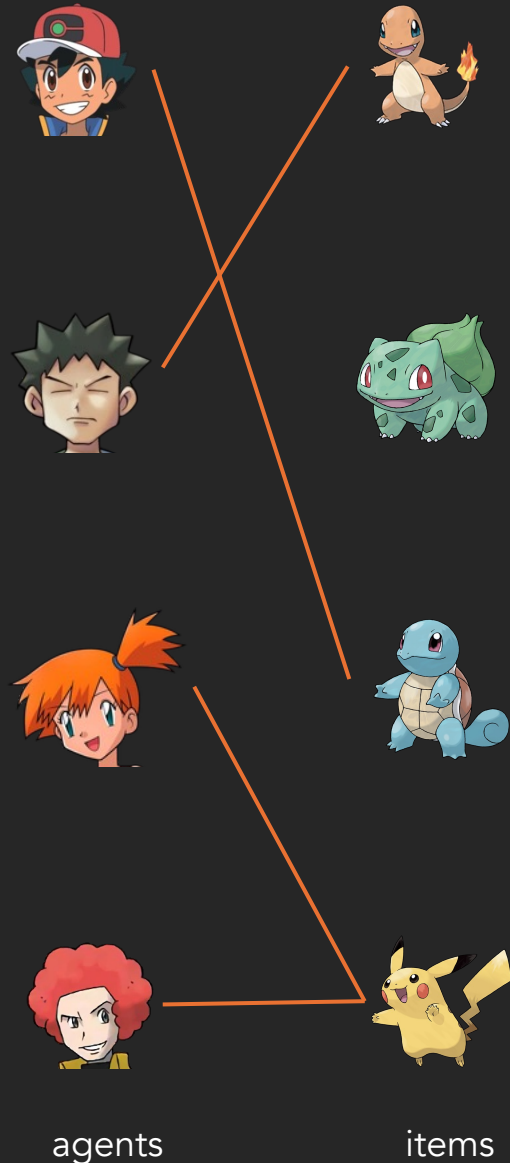
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Information Regimes

Information Regimes



No
Information

$$U = \rho \cdot q(i) + (1 - \rho) \cdot \varphi(a, i)$$

Information Regimes

Agents choose
items randomly

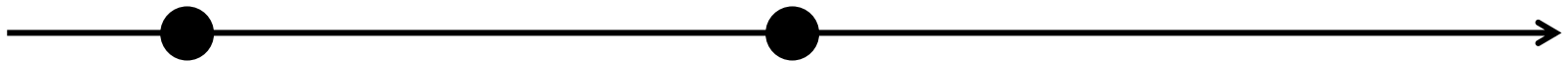


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Information Regimes

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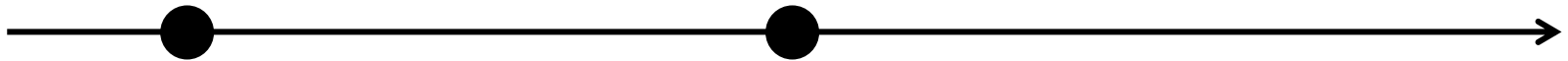
No
Information

Partial
Information

$$U = \rho \cdot q(i) + (1 - \rho) \cdot \varphi(a, i) \quad U = \rho \cdot q(i) + (1 - \rho) \cdot \varphi(a, i)$$

Information Regimes

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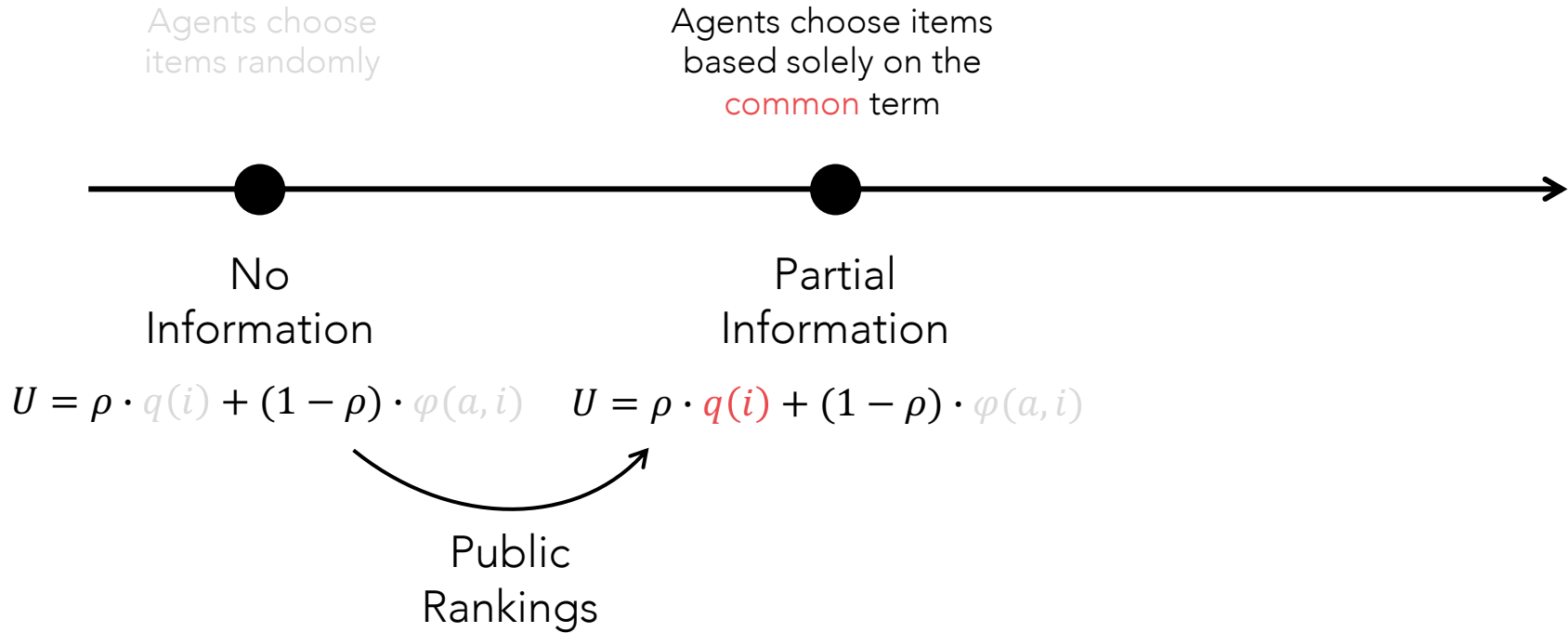
No
Information

Partial
Information

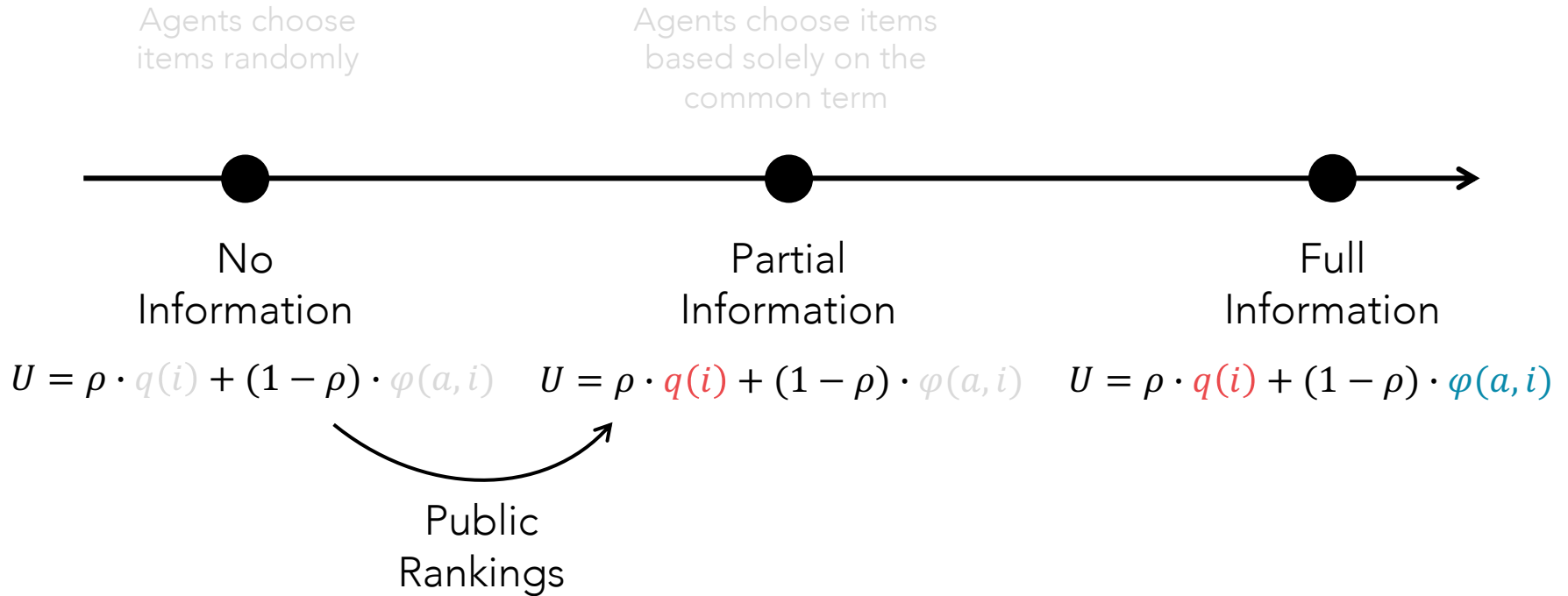
$$U = \rho \cdot q(i) + (1 - \rho) \cdot \varphi(a, i) \quad U = \rho \cdot q(i) + (1 - \rho) \cdot \varphi(a, i)$$

Public
Rankings

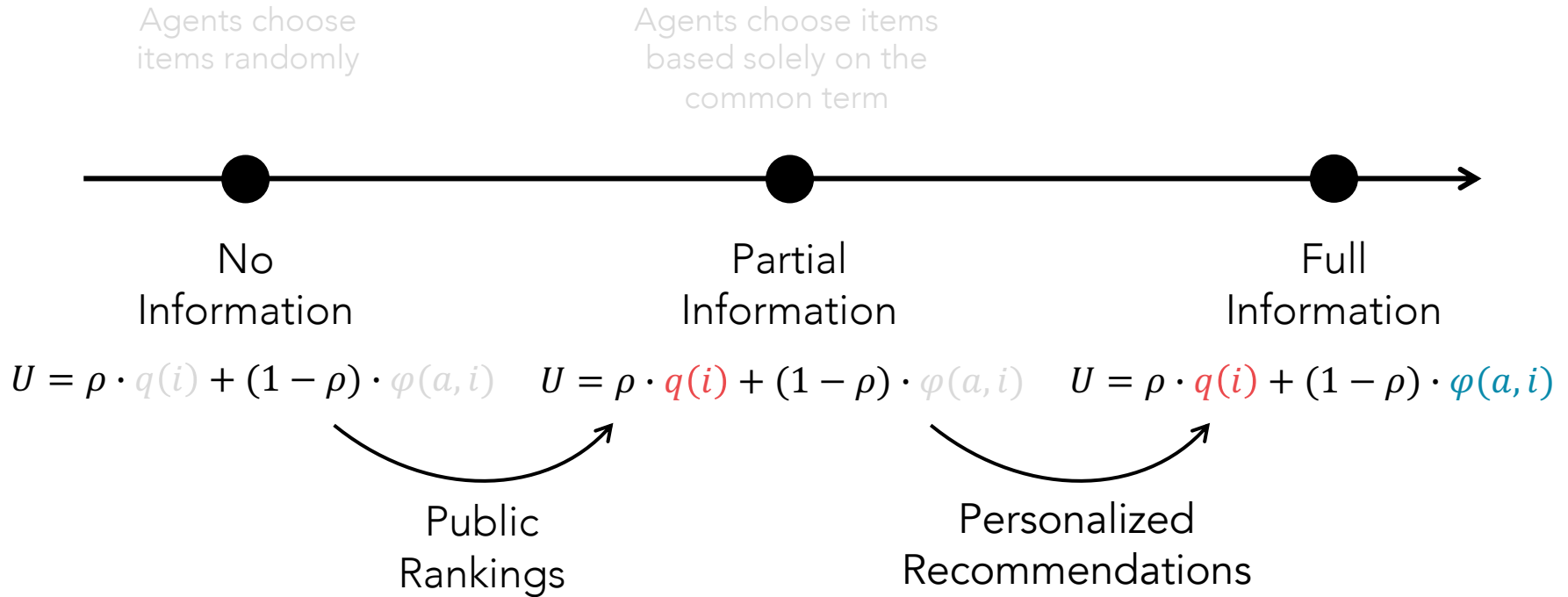
Information Regimes



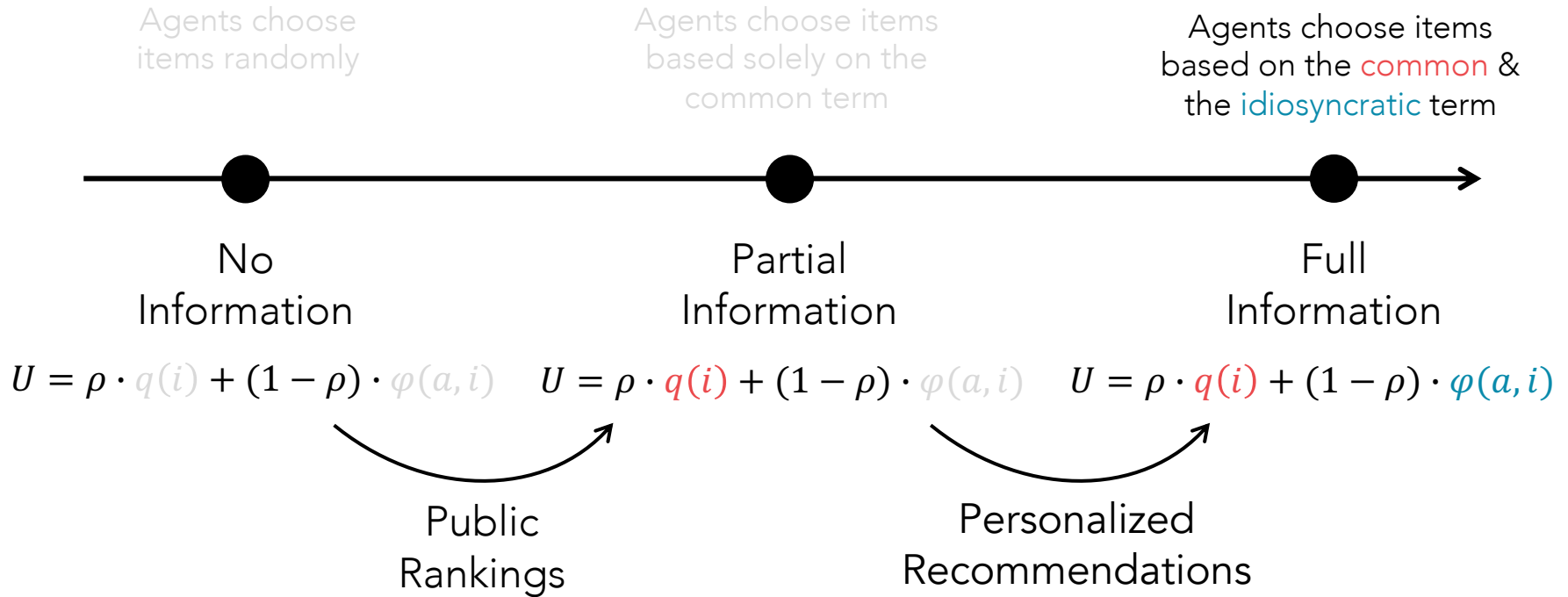
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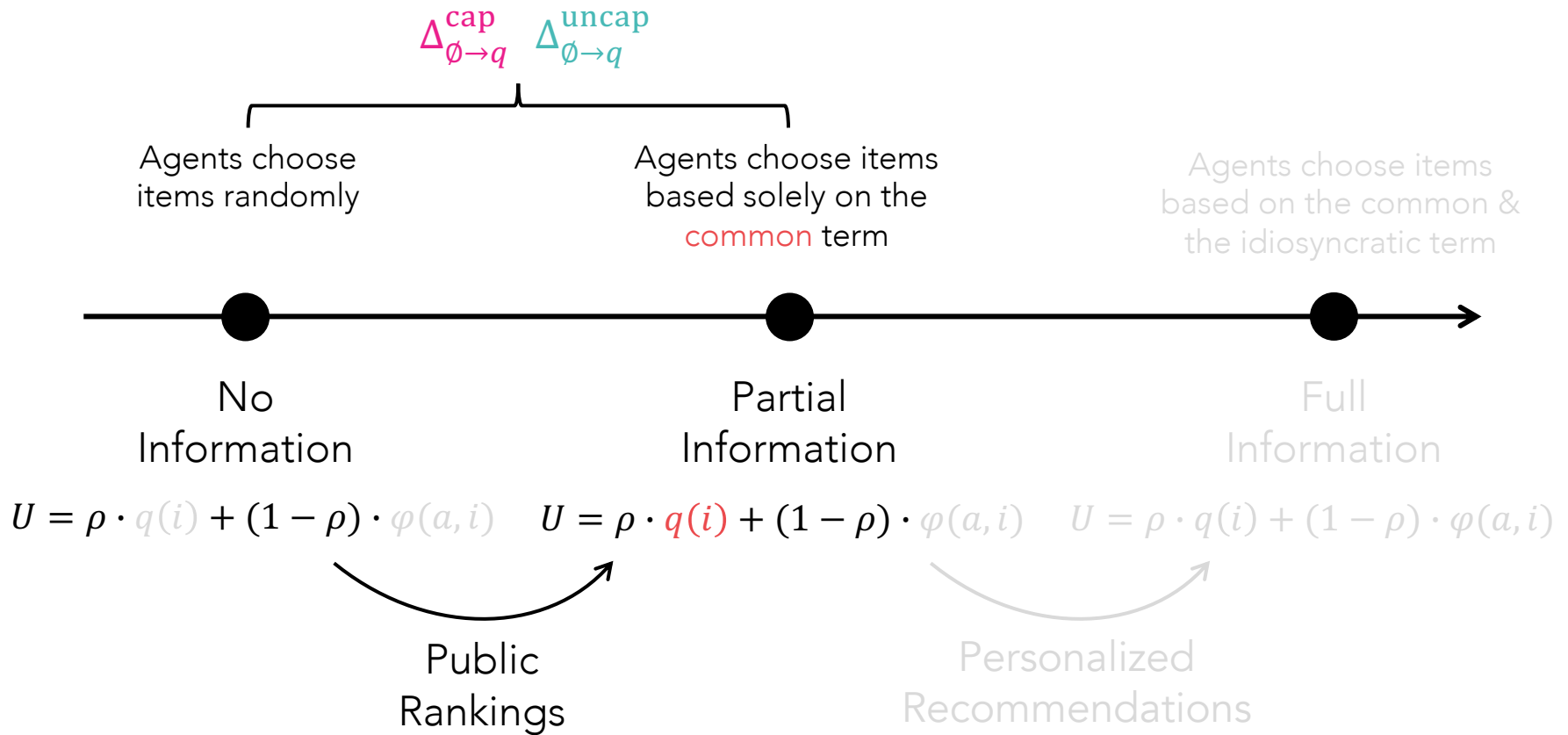
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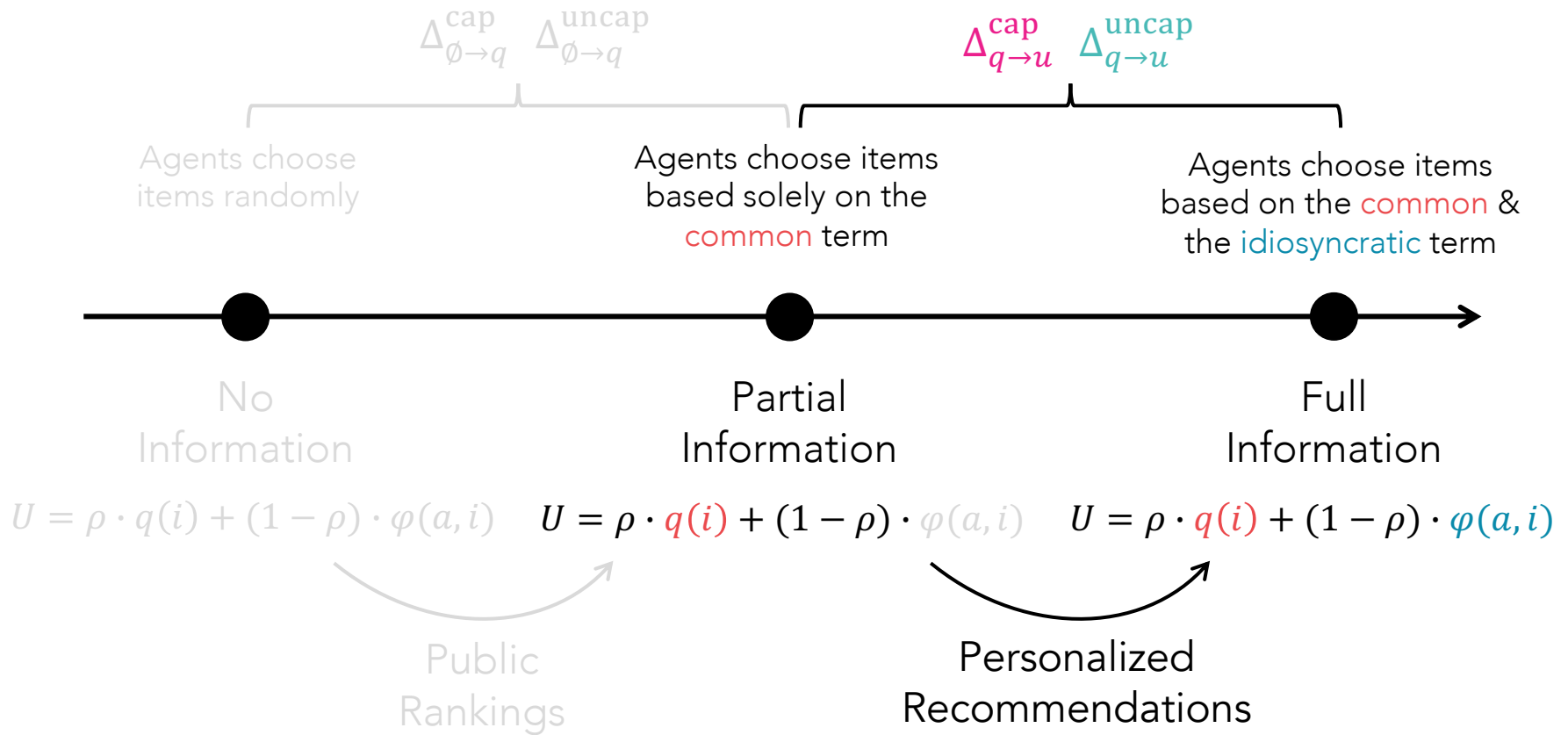
Information Regimes



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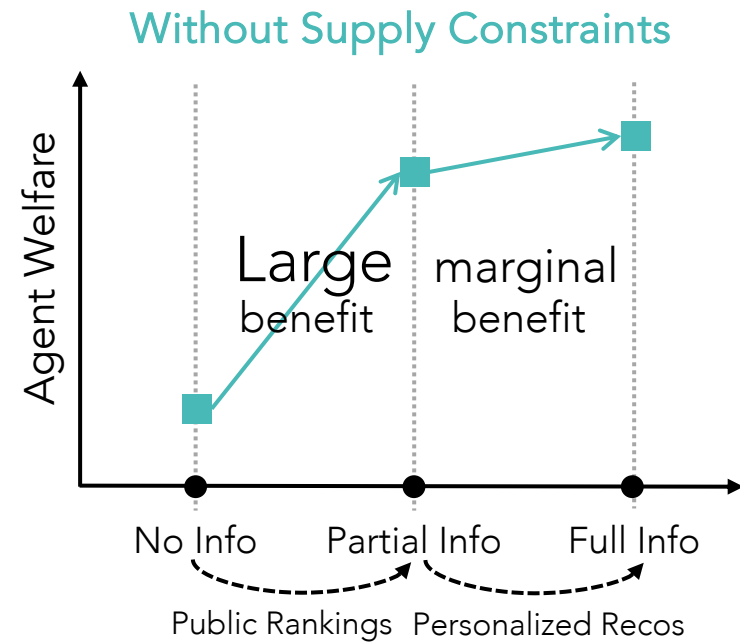
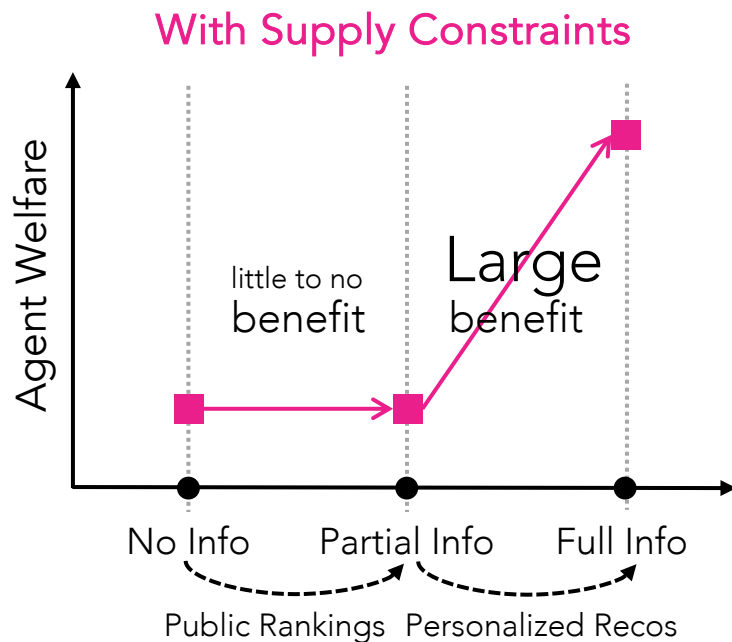


Information Regimes



Preview of Results

- Study the impact of two information provisioning tools
 - Public Rankings: Provide an overall assessment of the options
 - Personalized Recos: Helps discover agent-item specific adjustments
- Analyze a stylized model to isolate the impact of these tools
- Identify a fundamental interplay between the value of these information provisioning tools and supply-side constraints



Main Result (Pareto Tail)

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We have n agents and n items. Assume that common term distribution F_q and the idiosyncratic term distribution F_φ have Pareto tail with parameters (κ, α) . Then we have that

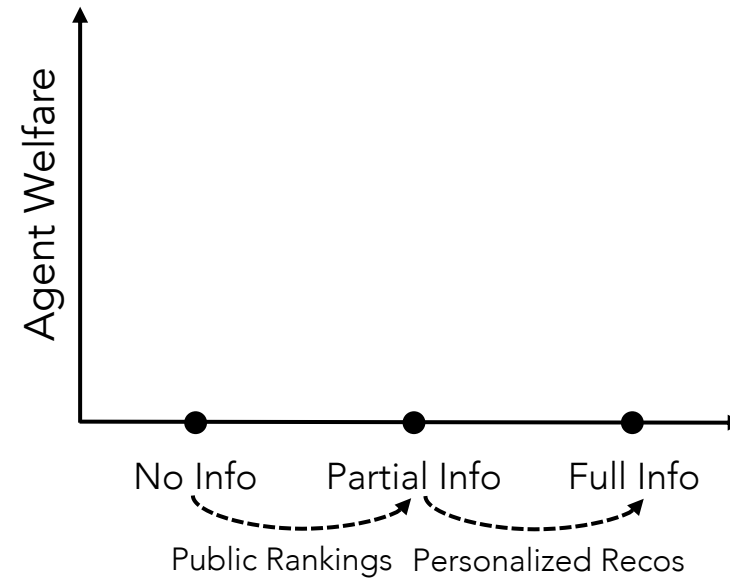
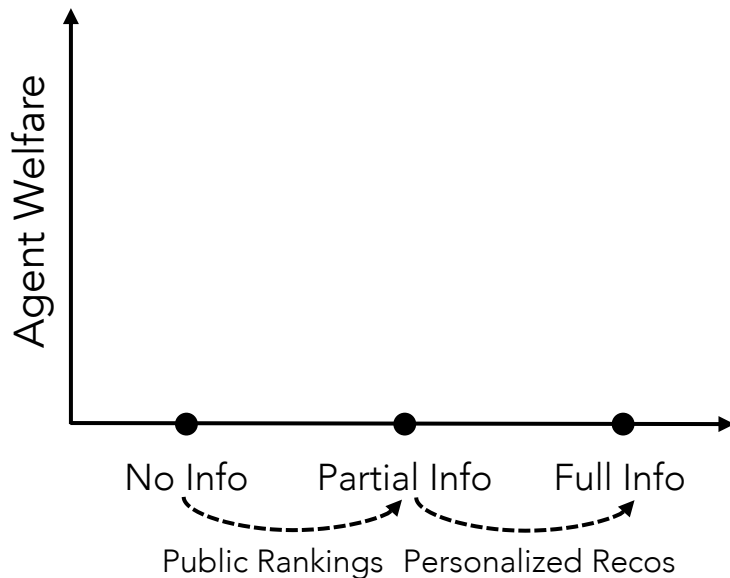
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Capacitated Supply Setting

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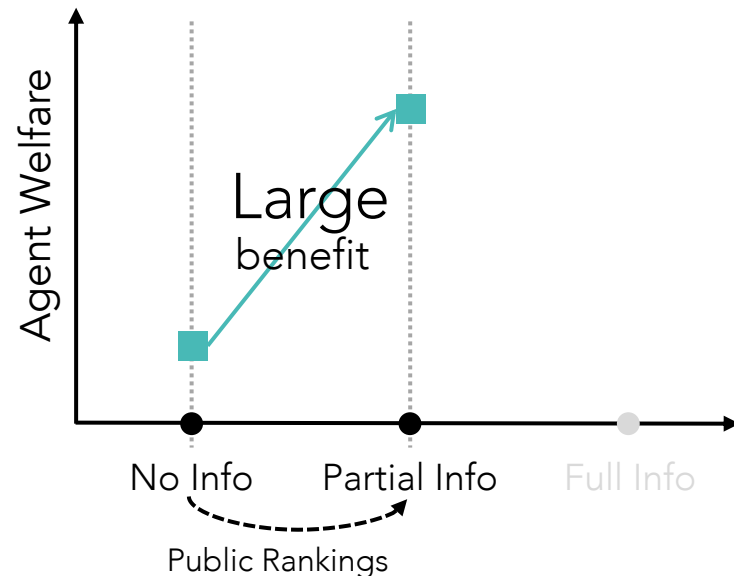
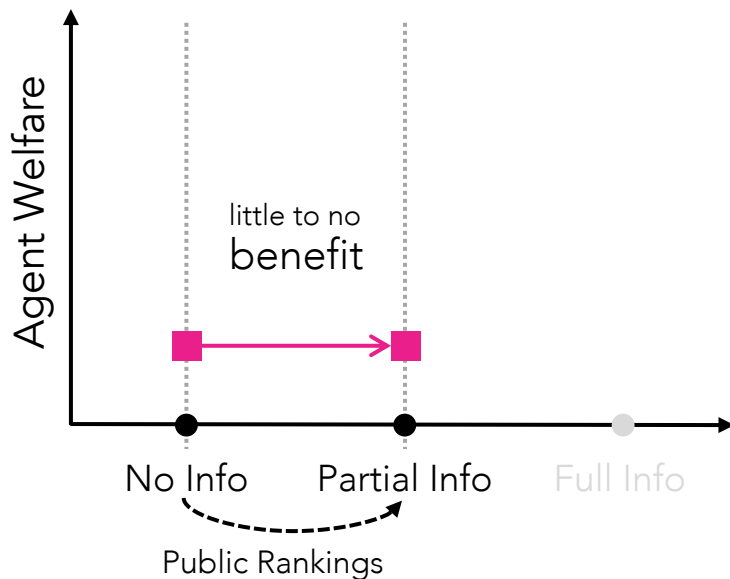
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- $\Delta_{\emptyset \rightarrow q}^{\text{cap}} = 0$

Uncapacitated Supply Setting

- $\Delta_{\emptyset \rightarrow q}^{\text{uncap}} \simeq c\rho \cdot n^{1/\alpha}$



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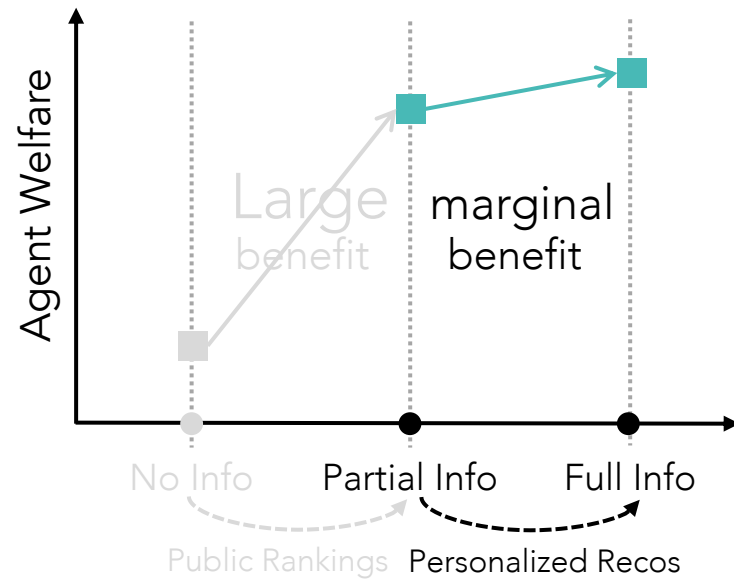
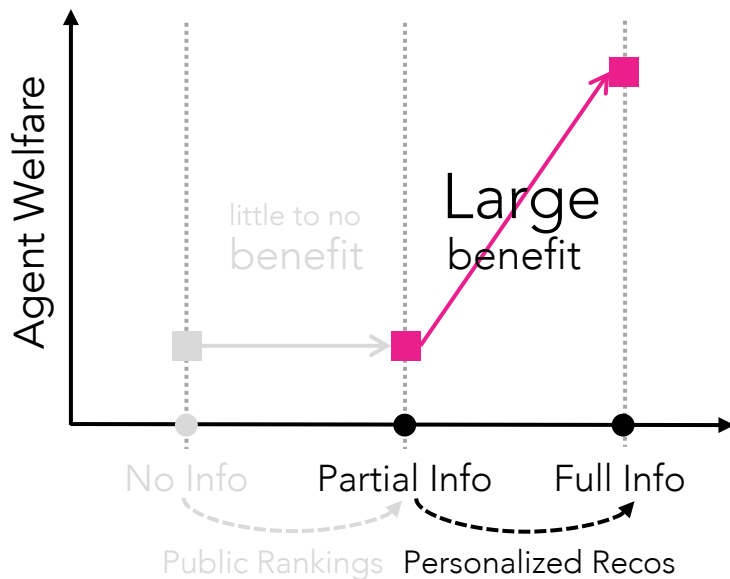
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- $\Delta_{\theta \rightarrow q}^{\text{cap}} = 0$
- $\Delta_{q \rightarrow u}^{\text{cap}} \simeq c(1 - \rho) \cdot n^{1/\alpha}$

Uncapacitated Supply Setting

- $\Delta_{\theta \rightarrow q}^{\text{uncap}} \simeq c\rho \cdot n^{1/\alpha}$
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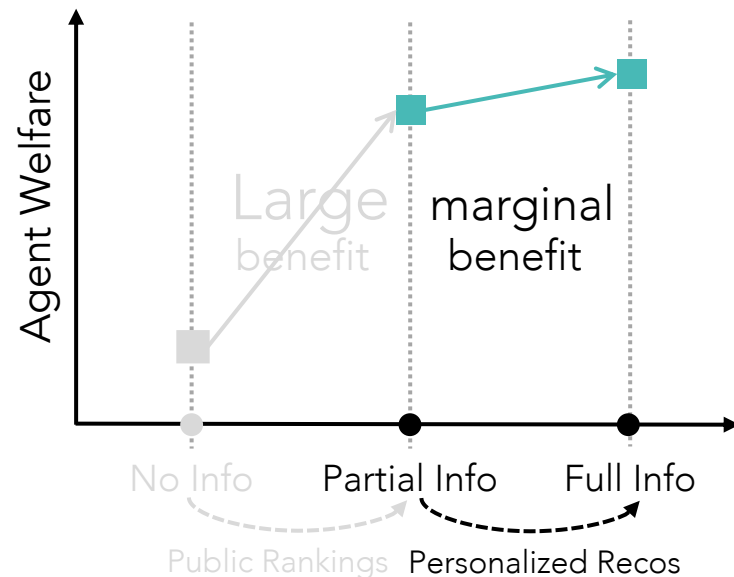
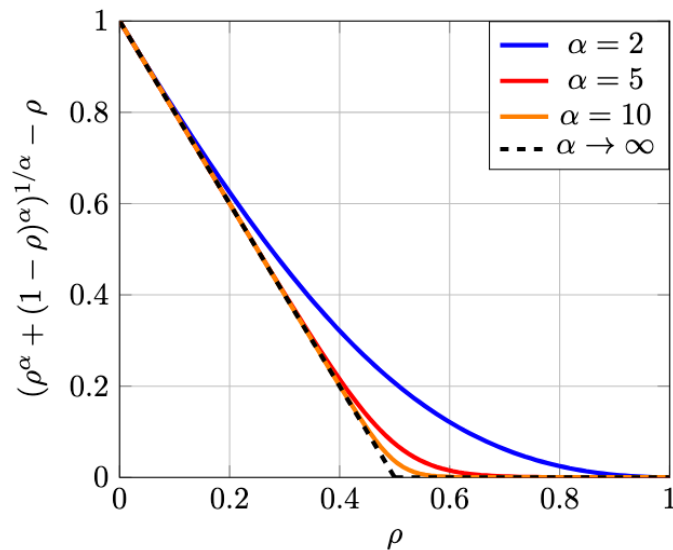
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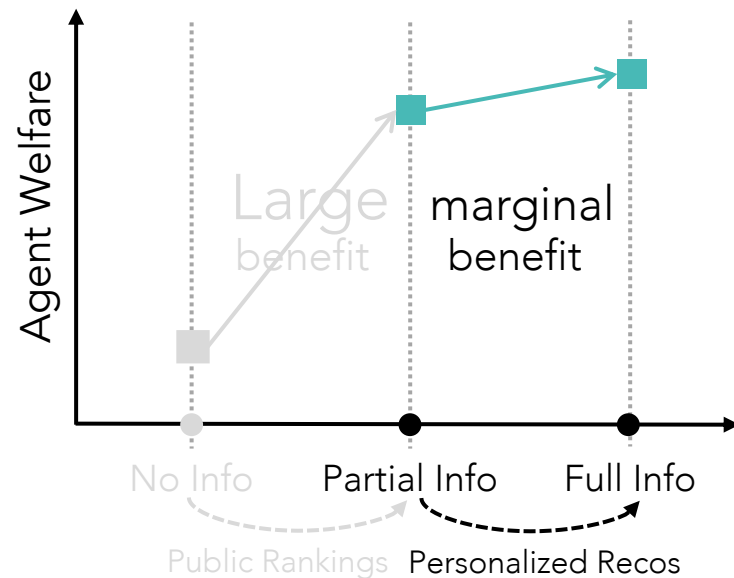
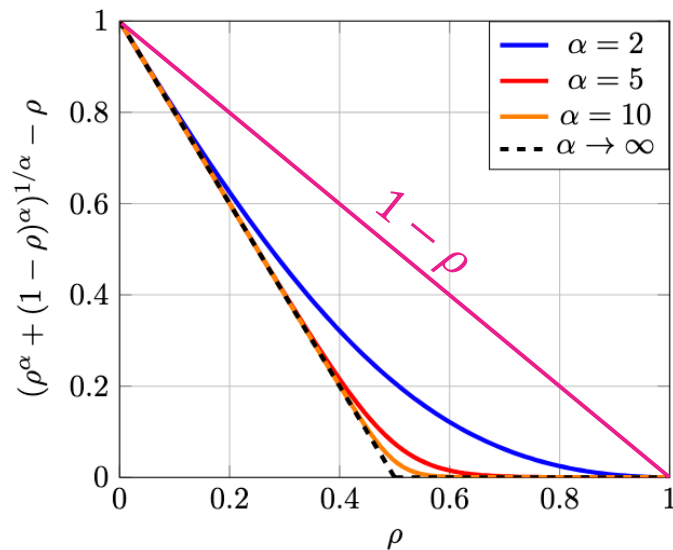
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Corollary (Exponential Tail)

A distribution F is said to have an exponential tail with parameter λ if $\lim_{x \rightarrow \infty} \bar{F}(x)/e^{-\lambda x} = 1$.

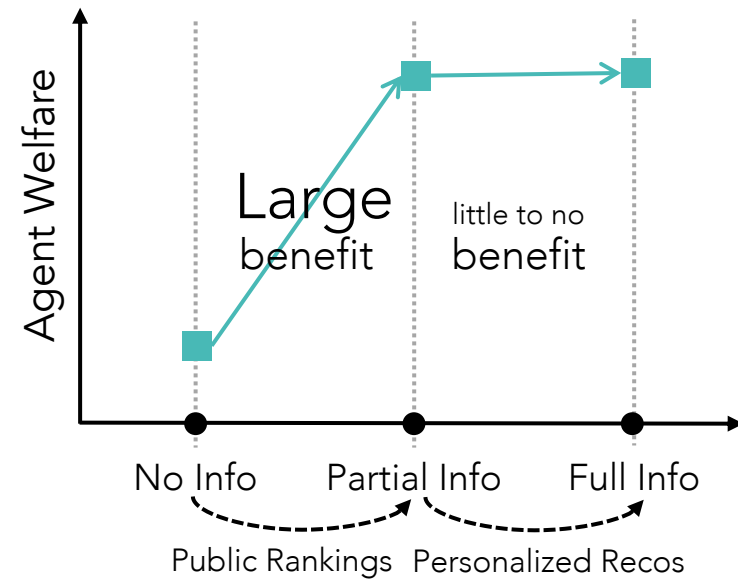
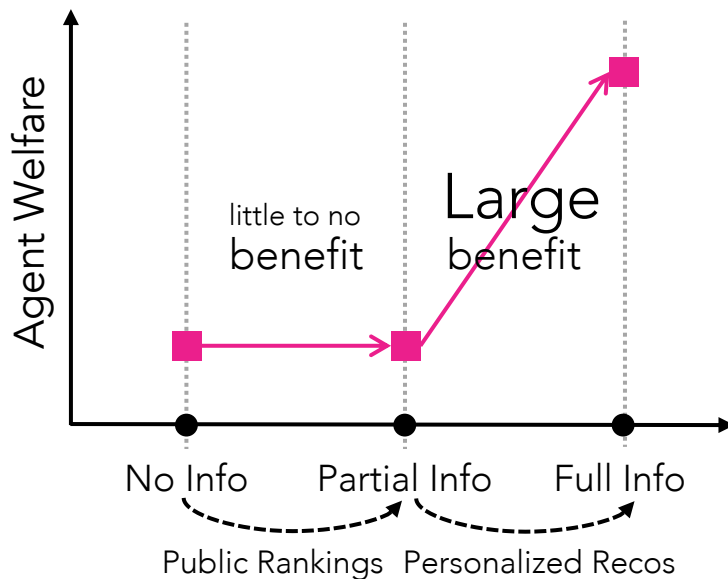
We have n agents and n items. Assume that common term distribution F_q and the idiosyncratic term distribution F_ϕ have exponential tail with parameter λ . Then we have that

Capacitated Supply Setting

- $\Delta_{\emptyset \rightarrow q}^{\text{cap}} = 0$
- $\Delta_{q \rightarrow u}^{\text{cap}} \simeq (1 - \rho) \cdot (\ln n / \lambda)$

Uncapacitated Supply Setting

- $\Delta_{\emptyset \rightarrow q}^{\text{uncap}} \simeq \rho \cdot (\ln n / \lambda)$
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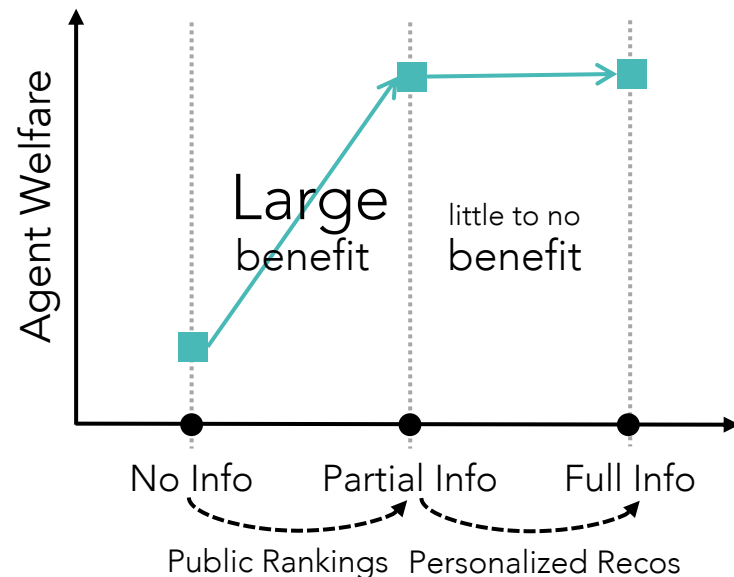
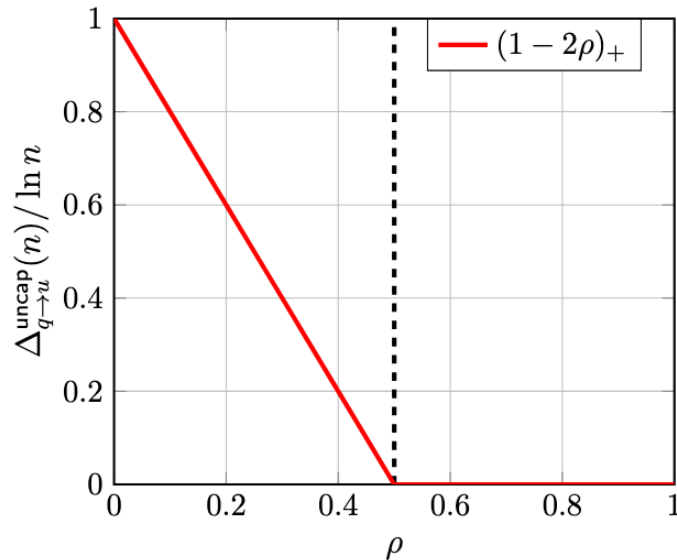
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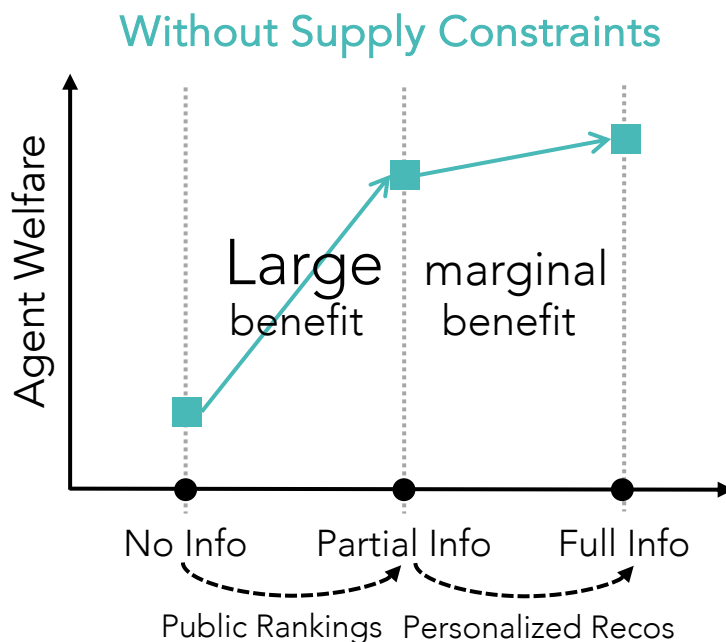
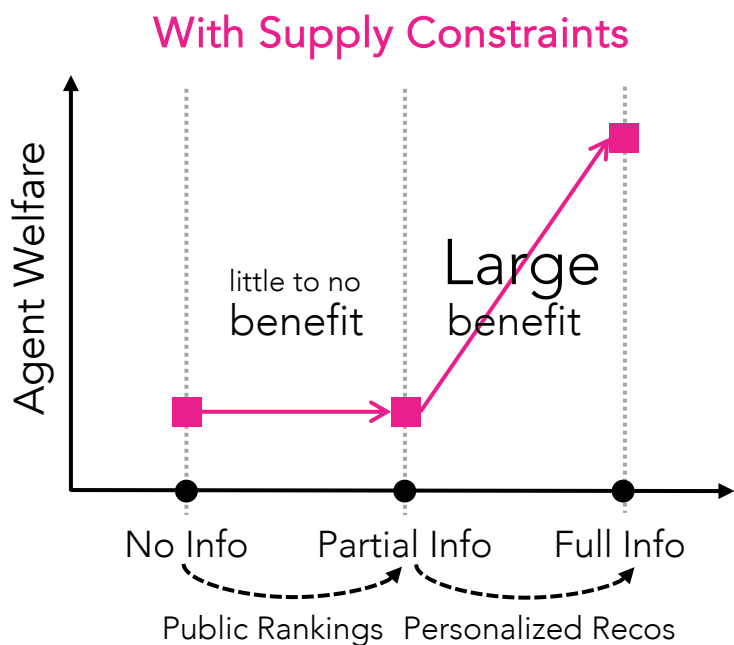
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Summary

- Study the impact of two information provisioning tools
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 - **Personalized Recos:** Helps discover agent-item specific adjustments
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So long and **Thanks** for all the fish