

Truthful mechanisms for ownership transfer with expert advice

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The setting

- One item for sale
- **Two potential buyers A and B**
 - Each buyer i has a **monetary value** w_i for the item
- **One expert**
 - The expert has **von Neumann-Morgenstern values** $v(\cdot)$ over the buyers, and the option \emptyset of not selling the item

Objectives

- Design **mechanisms** that
 - incentivize the buyers and the expert to **truthfully report** their preferences, and
 - decide the alternative $i \in \{A, B, \emptyset\}$ that maximizes the **social welfare**

$$SW(i) = \begin{cases} v(i) + \frac{w_i}{\max(w_A, w_B)}, & i \in \{A, B\} \\ v(\emptyset), & \text{otherwise} \end{cases}$$

Possible applications

- **Privatization of government companies**
 - Public water/energy companies
 - Potential buyers = private companies
 - Expert = citizens/consumers union
- **Sports tournaments hosting**
 - Football World Cup, Olympics, Formula 1
 - Potential buyers = countries that want to host the tournament
 - Expert = administrative body (FIFA, IOC, FIA)

Related literature

- **Mixture of approximate mechanism design**
 - **with money** for the buyers (Nisan & Ronen, 2001)
 - **without money** for the expert (Procaccia & Tennenholtz, 2013)

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 - VCG is **truthful + optimal** (Clarke, 1971, Groves, 1973, Vickrey, 1961)
 - However, **not** in our setting (due to the expert)
- **Computational social choice**
 - Ordinal non-dictatorial voting rules are **non-truthful** (Gibbard, 1973, Satterthwaite, 1975)
 - Many truthful randomized cardinal voting rules (Freixas, 1984, Barbera et al., 1998, Feige & tennenholtz, 2010)

Mechanisms and profiles

buyers' view



h	ℓ	n
1	y	0



expert's view



1	x	0
h	ℓ	z



Mechanisms and profiles

- A mechanism is a **lottery**, assigning probabilities to the alternatives

buyers' view



h	ℓ	n
1	y	0



$d(y, h, \ell, n)$ $c(y, h, \ell, n)$ $e(y, h, \ell, n)$

expert's view



1	x	0
h	ℓ	z



$g(x, h, \ell, z)$ $f(x, h, \ell, z)$ $\eta(x, h, \ell, z)$

Mechanisms and profiles: example

- $\Pr[\text{green}] = 0.2$, $\Pr[\text{red}] = 0.5$, $\Pr[\text{no sale}] = 0.3$

buyers' view



0.4	0	1
1	0.65	0



0.2



0.5



0.3

expert's view



1	0.4	0
0	1	0.65



0.3



0.2



0.5

Truthfulness conditions

- A mechanism is truthful iff it is



0	1	0.8
1	0.7	0



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 - Expert level change incentive compatible (**ECh-IC**)



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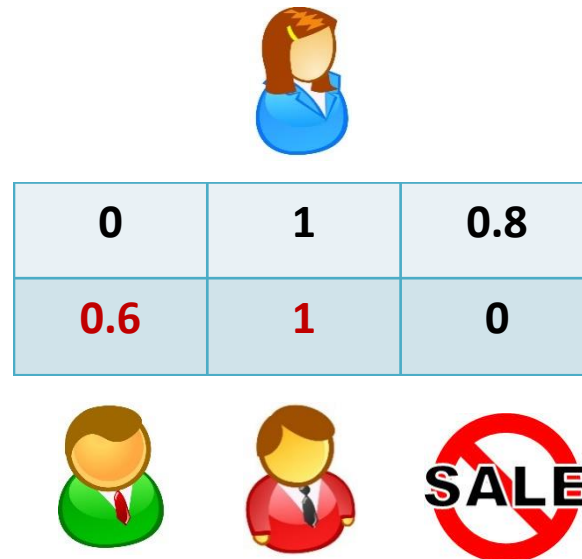
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The diagram illustrates a mechanism involving an expert and two buyers. The expert's strategy space is {0, 1} and the buyers' strategy space is {0, 1}. The expert's utility is given by the top row of the table, and the buyers' utility is given by the bottom row. The third column represents a 'No Sale' outcome.

Truthfulness conditions

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 - Expert swap incentive compatible (**ESw-IC**)
 - Buyer level change incentive compatible (**BCh-IC**)
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0	1	0.8
0.6	1	0

Characterizations of truthfulness

- A mechanism is **BCh-IC** iff the functions $d(y, h, \ell, n)$ and $c(y, h, \ell, n)$ are non-increasing and non-decreasing in y , respectively
 - ⇒ There exist payments to force the buyers to be truthful
 - Myerson (1981)

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 - Myerson (1981)
- A mechanism is **ECh-IC** iff the function $f(x, h, \ell, z)$ is non-decreasing in x , and

$$g(x, \cdot) = g(0, \cdot) - xf(x, \cdot) + \int_0^x f(t, \cdot) dt$$

Overview of results

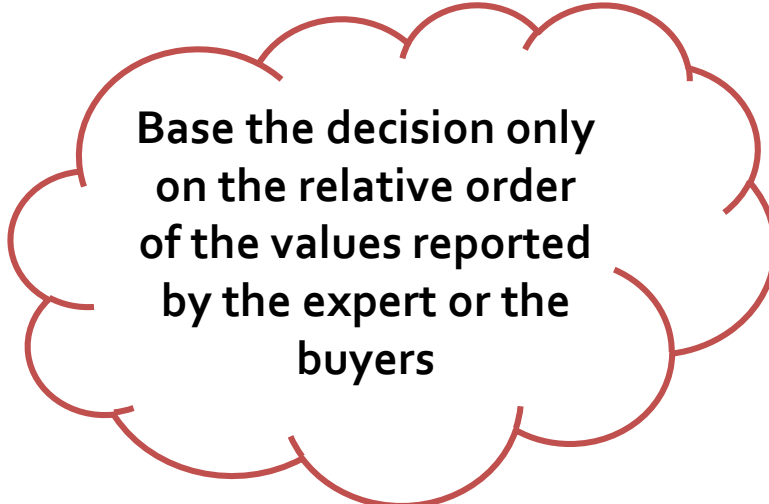
- Several classes of truthful mechanisms, depending on different informational assumptions
- For each class, we identify the best possible mechanism in terms of approximation of max social welfare

mechanism class	apx. ratio
ordinal	1.5
bid-independent	1.377
expert-independent	1.343
randomized template	1.25
deterministic template	1.618
deterministic	≥ 1.618
all	≥ 1.14

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Base the decision only
on the relative order
of the values reported
by the expert or the
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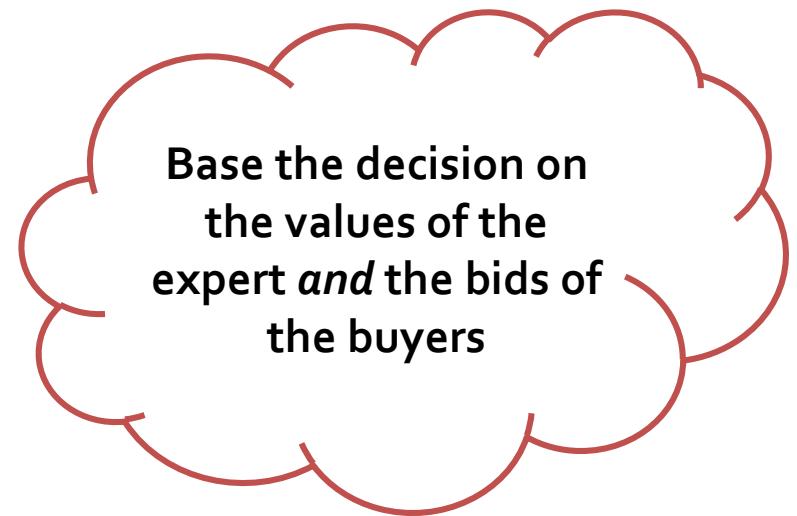
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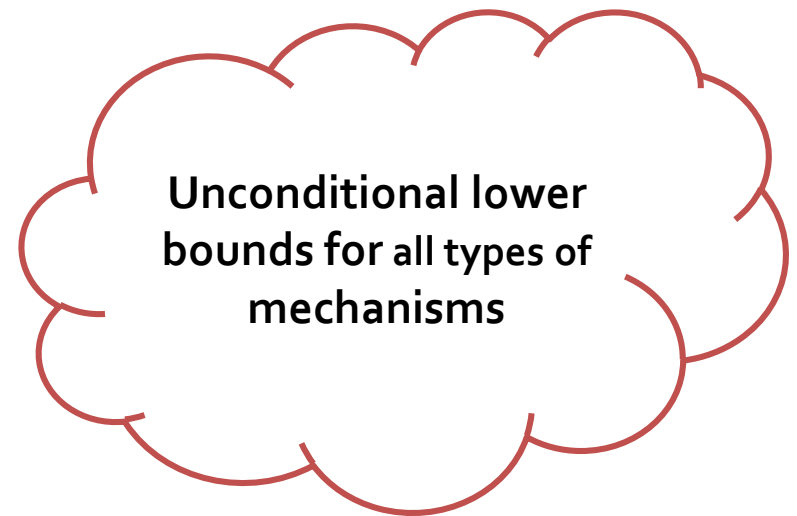
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Template mechanisms

- **Use the bids of the buyers + one bit of information by the expert**
 - Category T1 includes profiles with $\ell \geq h$
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Template mechanisms

- **Use the bids of the buyers + one bit of information by the expert**
 - Category T1 includes profiles with $\ell \geq h$
 - Category T2 includes all other profiles
- **For every profile in T1:**
 - select the low-bidder with probability $c(y, T1)$
 - select the high-bidder with probability $1 - c(y, T1)$
 - $c(y, T1)$ is non-decreasing in y
- **For every profile in T2:**
 - select the high-bidder with probability 1



h	ℓ	n
1	y	0

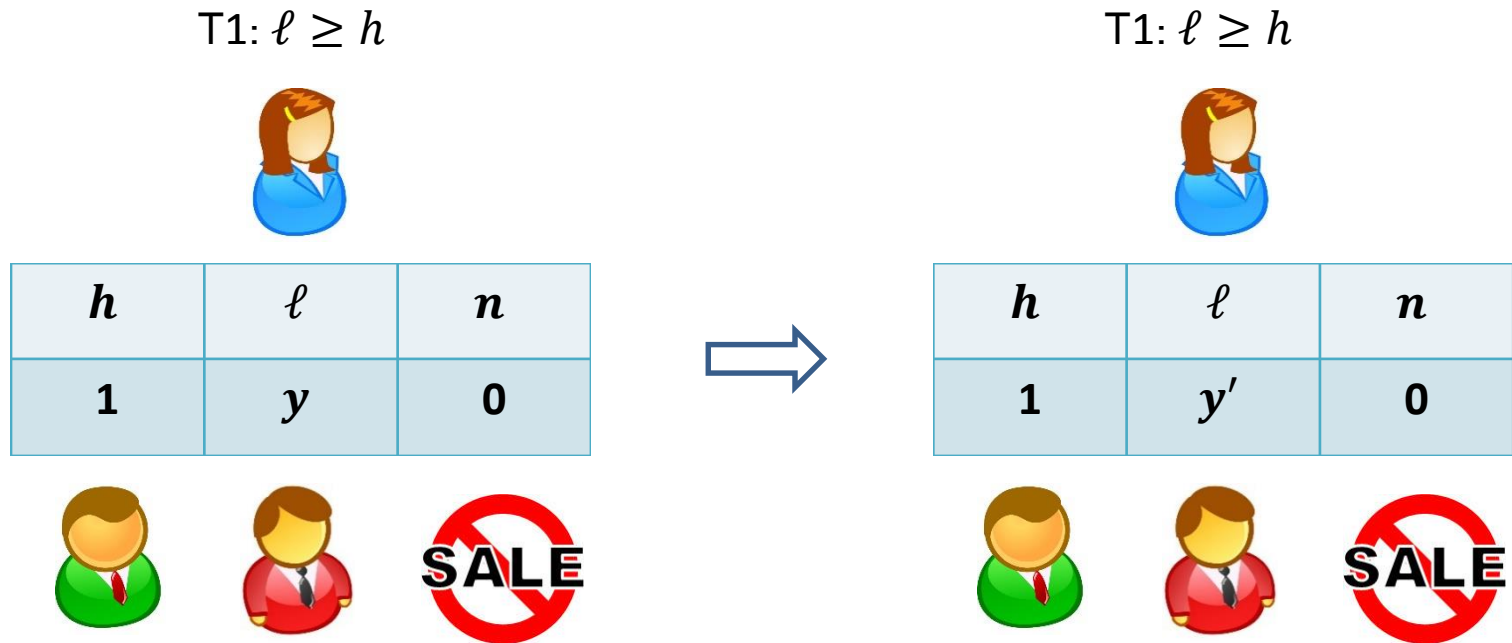


Template mechanisms: truthfulness

- **Level changes** by the buyers or the expert lead to profiles of the **same** category

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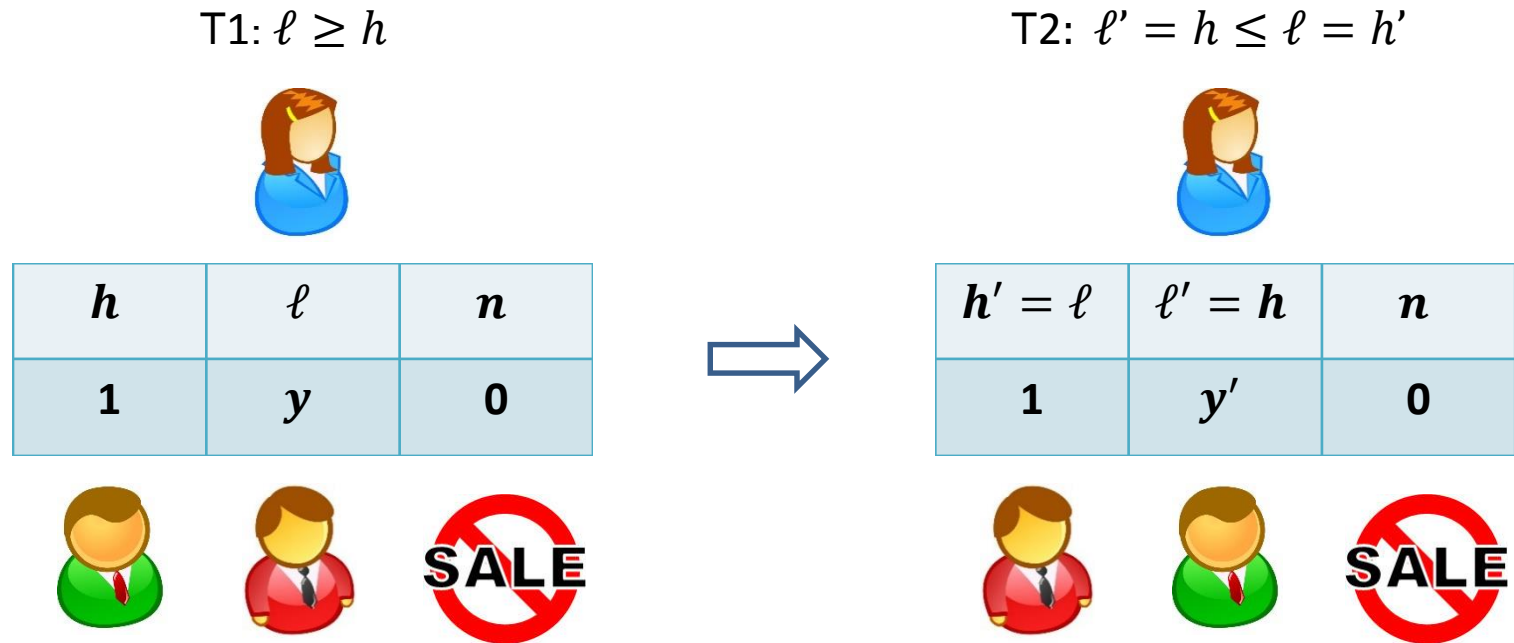
- **Level changes** by the buyers or the expert lead to profiles of the same category
 - **BCh-IC:** Myerson + monotonicity of function c
 - **ECh-IC:** The corresponding probability functions as seen by the expert are constant

Template mechanisms: truthfulness

- **Swaps** by the buyers or the expert lead to profiles of **different** category

Template mechanisms: truthfulness

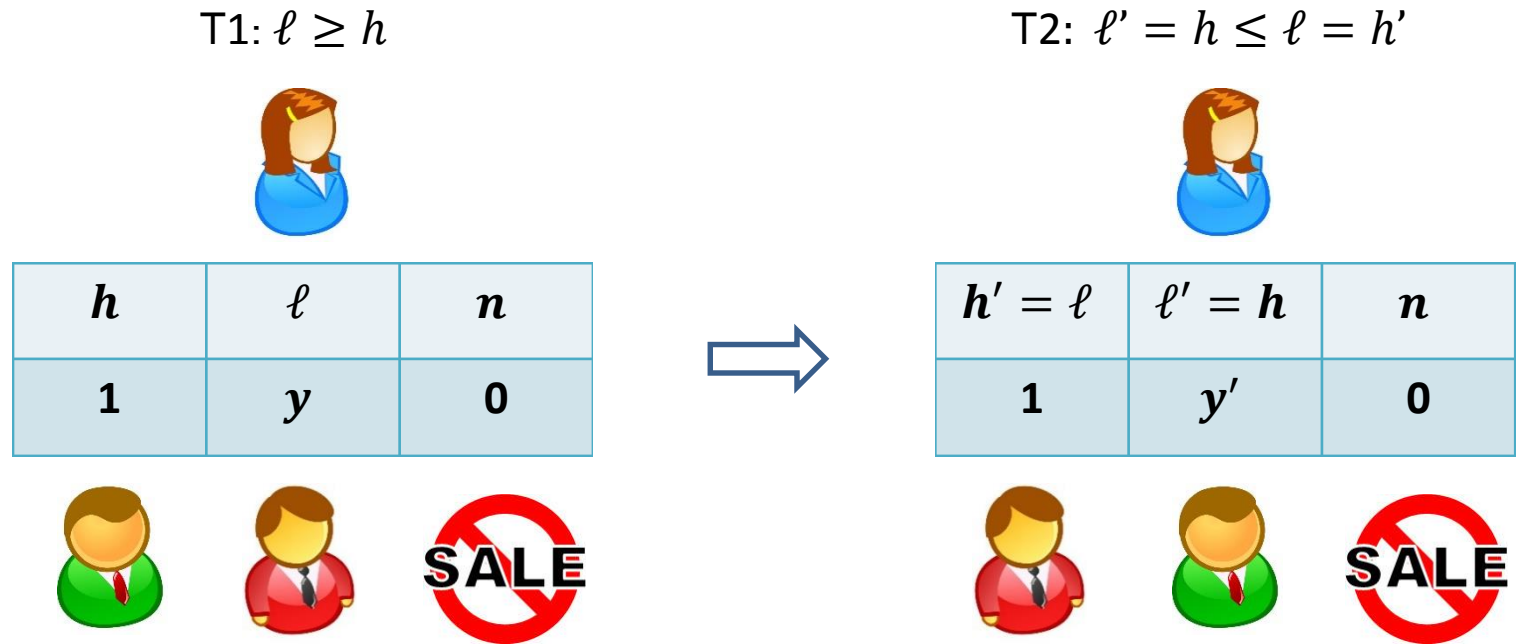
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Template mechanisms: truthfulness

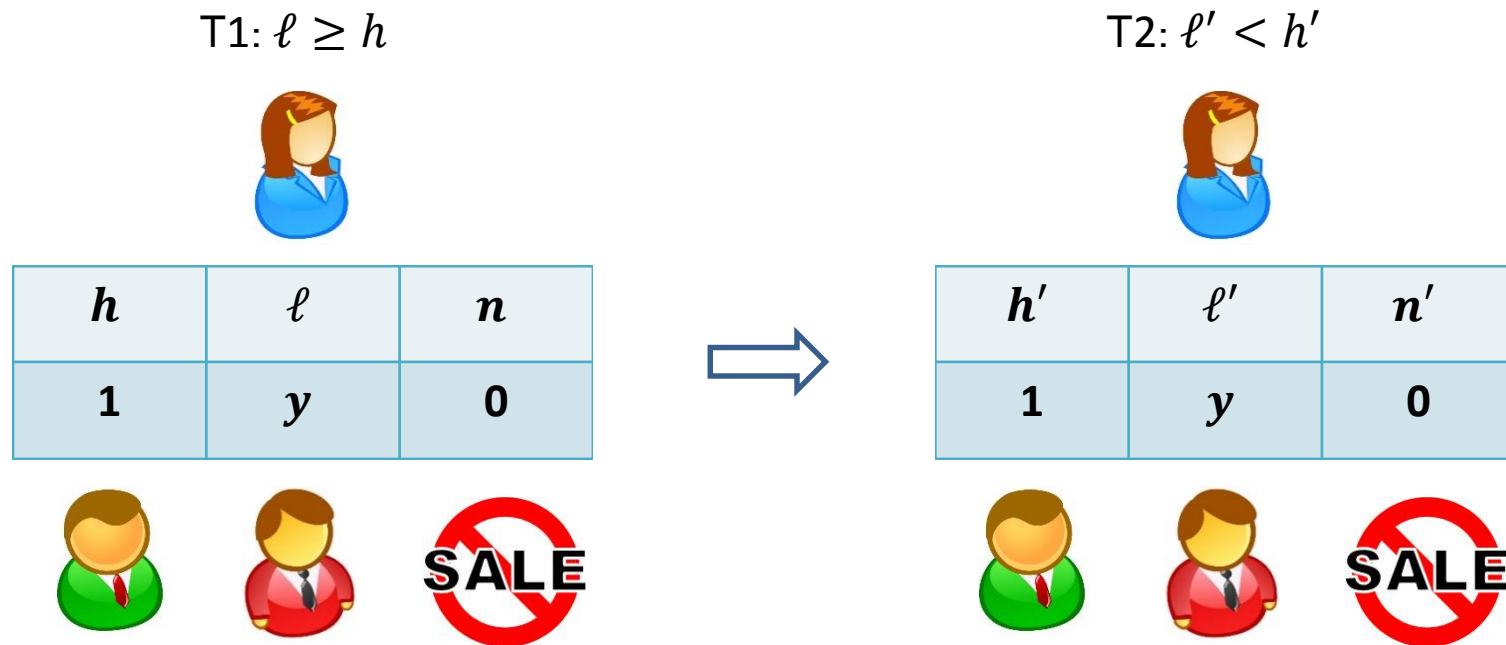


- If deviant = low-bidder \Rightarrow **increases her bid**, becomes the high-bidder and her **selection probability increases** from $c(y, T1)$ to 1
- If deviant = high-bidder \Rightarrow **decreases her bid**, becomes the low-bidder and her **selection probability decreases** from $1 - c(y', T1)$ to 0

Template mechanisms: truthfulness

- **Swaps** by the buyers or the expert lead to profiles of **different** category
 - **BSw-IC**: increase/decrease of deviating bid follows increase/decrease of selection probability
 - **ESw-IC**: the expected utility of the expert does not increase

Template mechanisms: truthfulness



- Utility in T1 = $h(1 - c(y, T1)) + \ell c(y, T1) = h + (\ell - h)c(y, T1) \geq h$
- Utility in T2 = h

Template mechanisms: approximation

- Which function $c(y, T1)$ minimizes the approximation ratio?

Template mechanisms: approximation

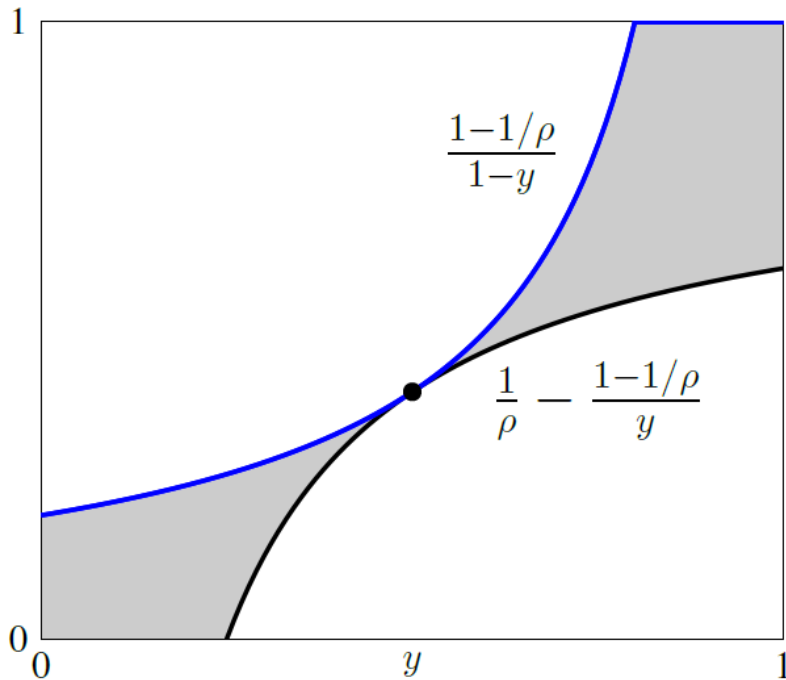
- Which function $c(y, T1)$ minimizes the approximation ratio?
- A template mechanism has approximation ratio at most ρ iff

$$\frac{1}{\rho} - \frac{1 - 1/\rho}{y} \leq c(y, T1) \leq \frac{1 - 1/\rho}{1 - y}$$

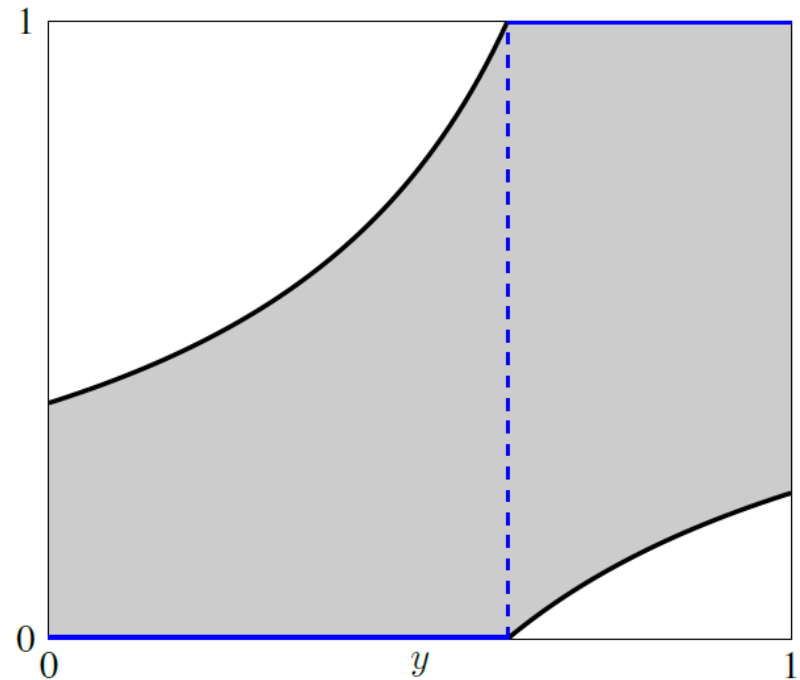
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$$\rho = 5/4$$



$$\rho = \varphi$$

Extensions

- What is the best possible achievable approximation ratio?
- Generalizations of the social welfare to weigh differently the contribution of the expert and the buyers
- Revenue
- Expert valuations that depend on the bids
- More buyers and experts

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Thank you!