Bundling in Oligopoly: Revenue Maximization with Single-Item Competitors

Moshe Babaioff (Hebrew University of Jerusalem),
Linda Cai (Princeton University), Brendan Lucier (Microsoft Research)




Revenue Maximizing Auction – Monopolist Seller

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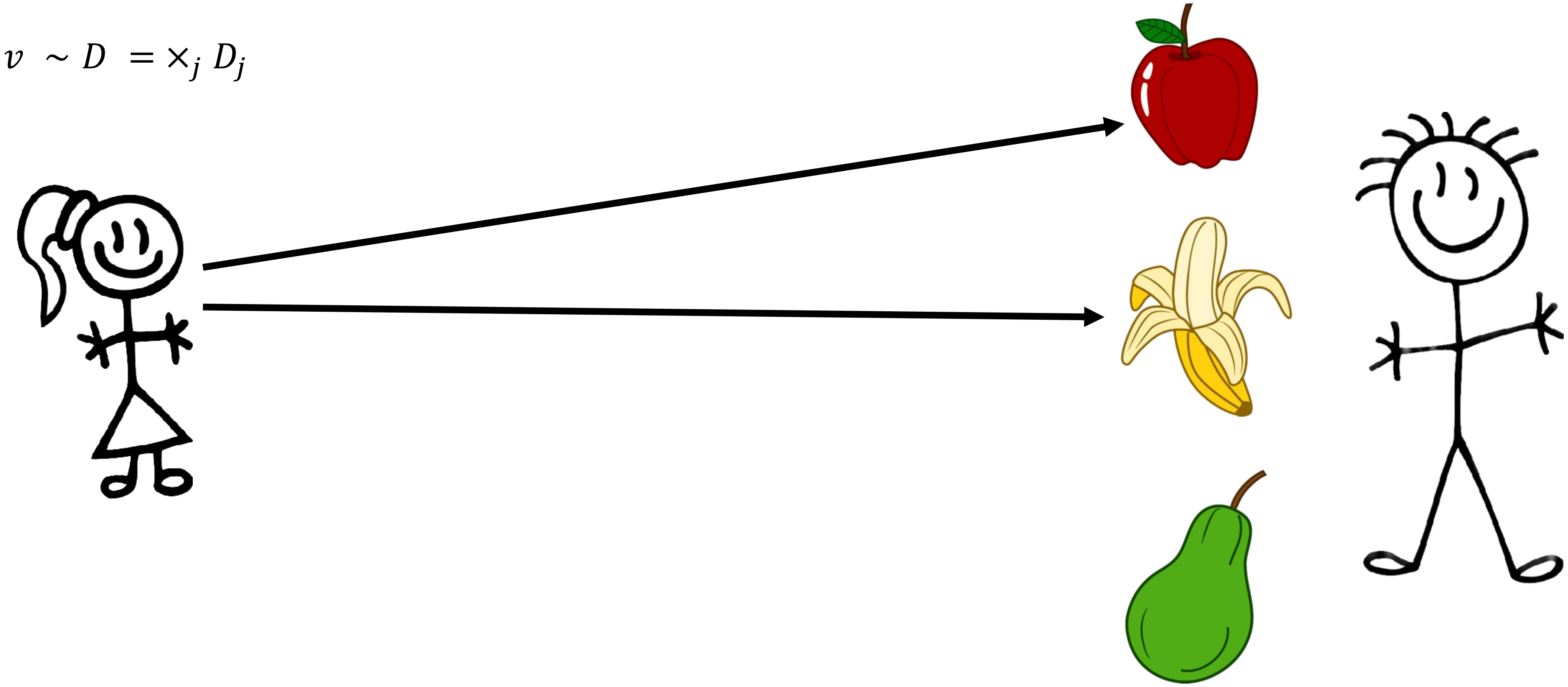

One Principal Seller with m items, One buyer with additive valuation function

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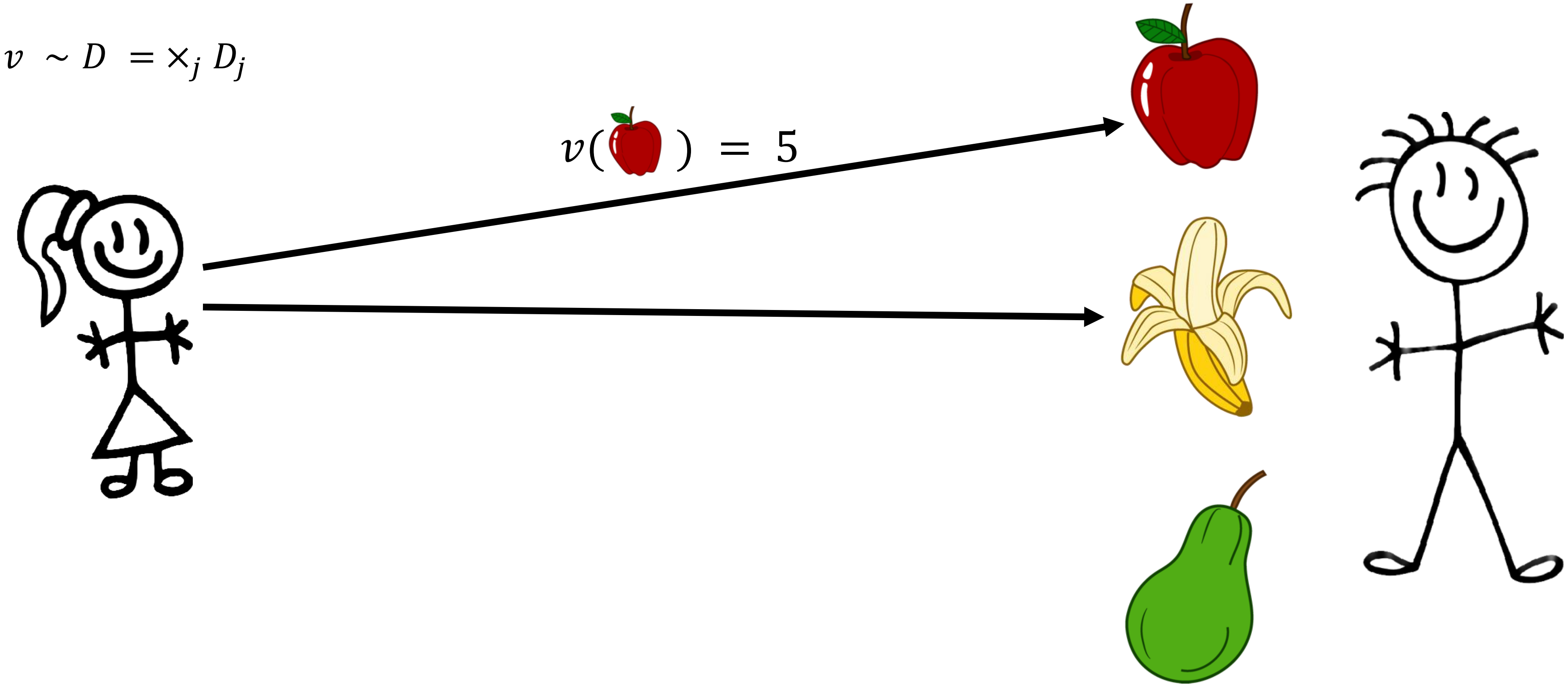

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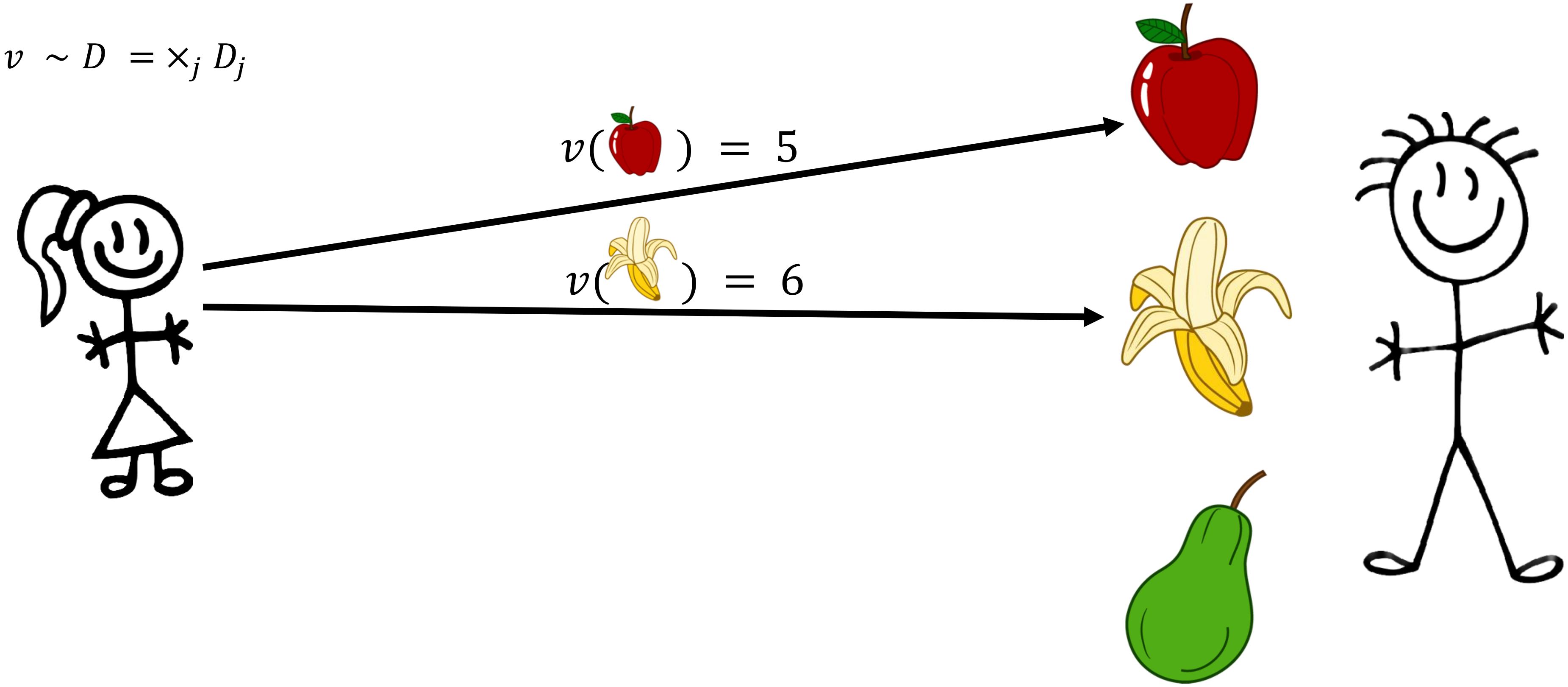

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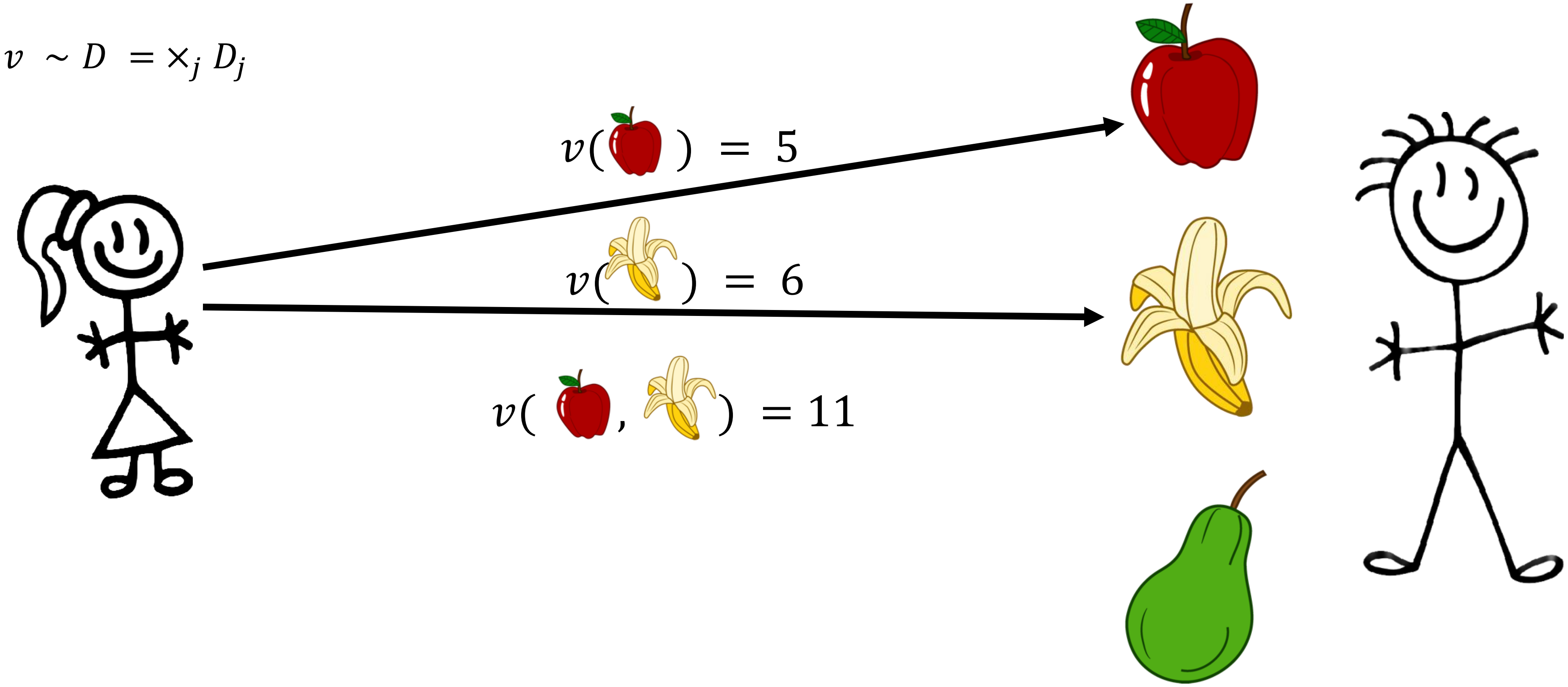

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True Monopoly is Rare

Even dominant sellers often face sub-category competition who offer similar products.

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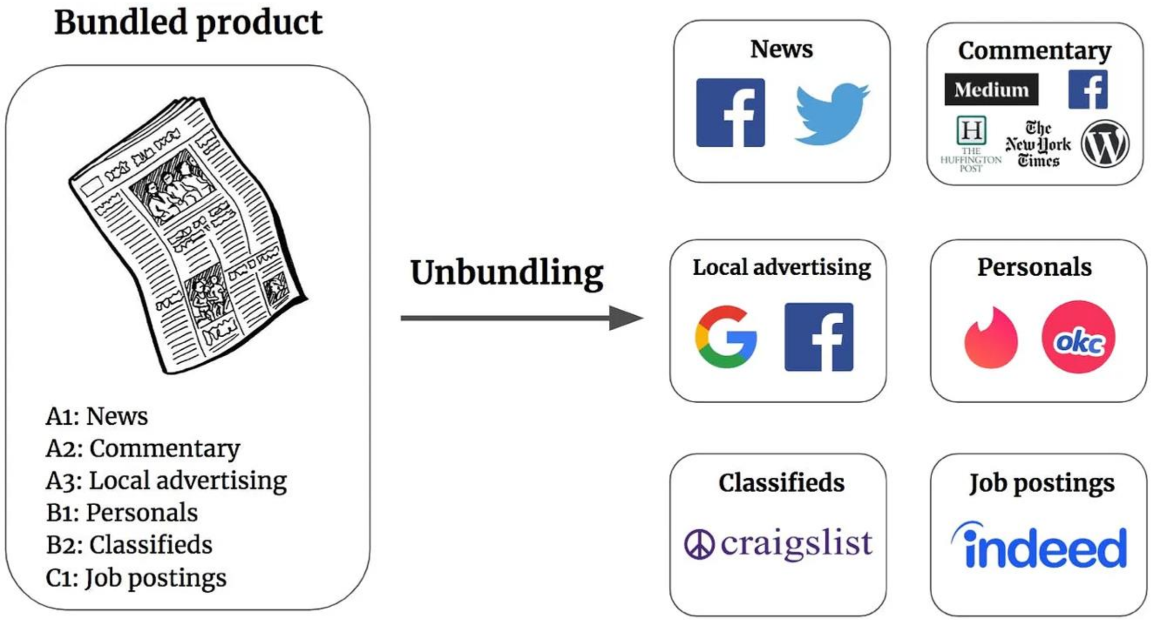

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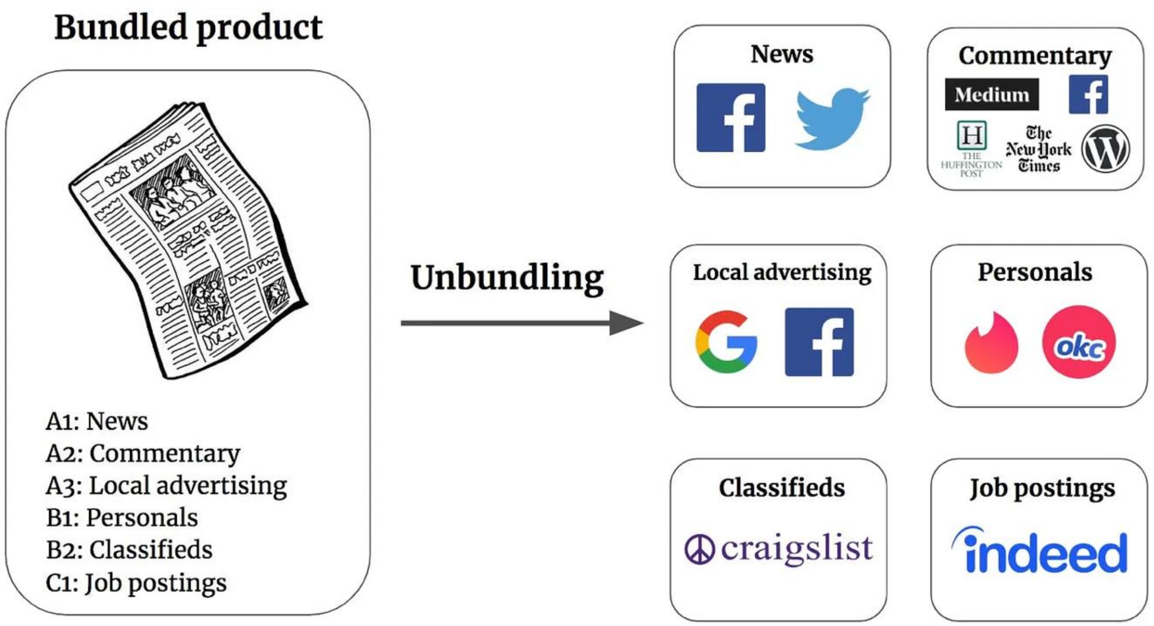

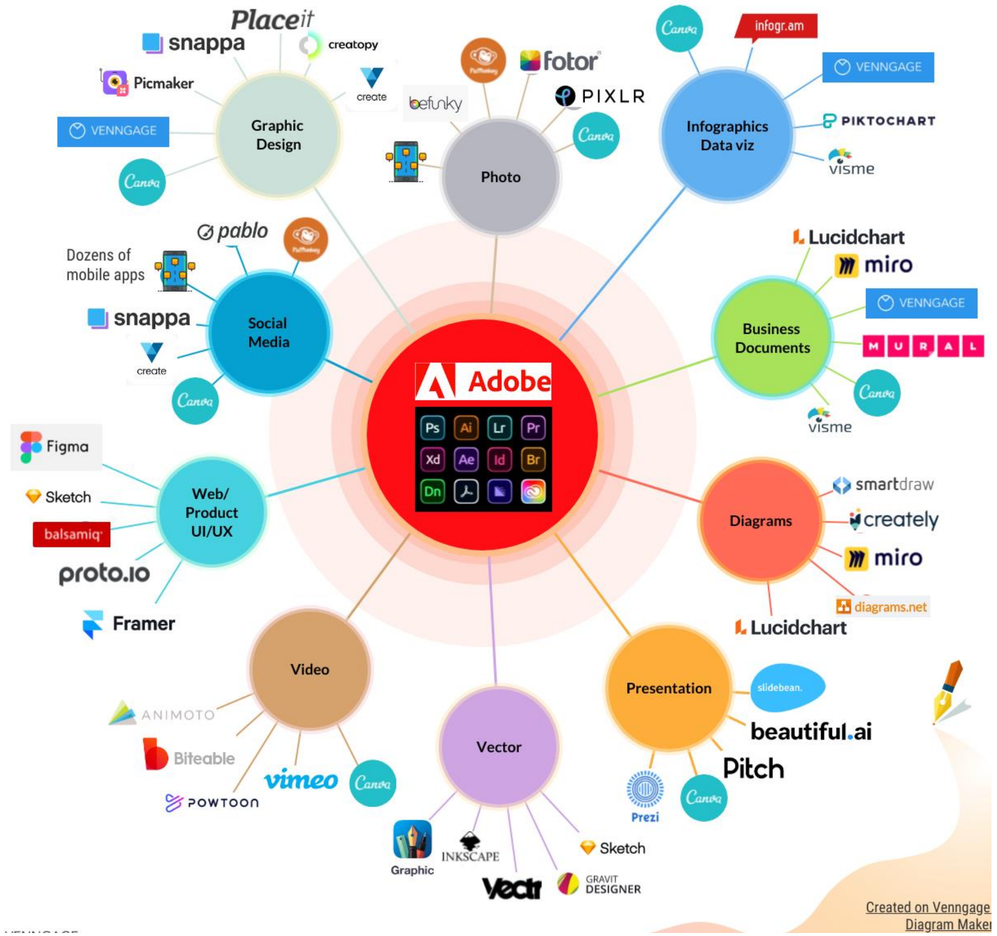

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Revenue Maximizing Auction – Our Model

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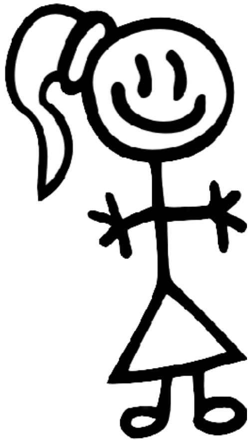
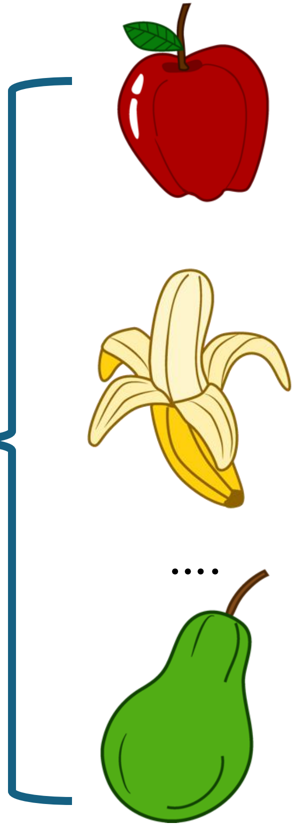
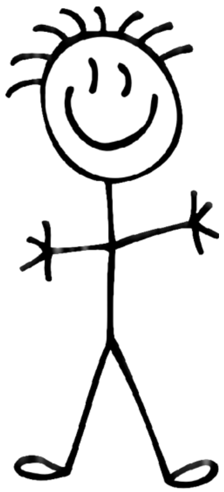


Single Multi-good Seller (Principal Seller)

m items





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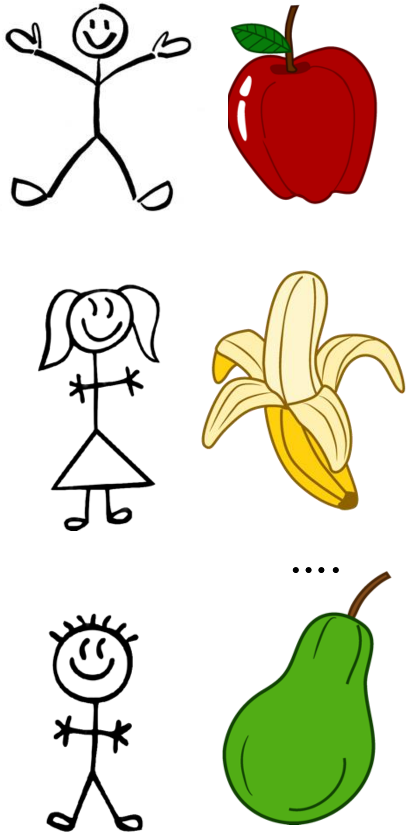

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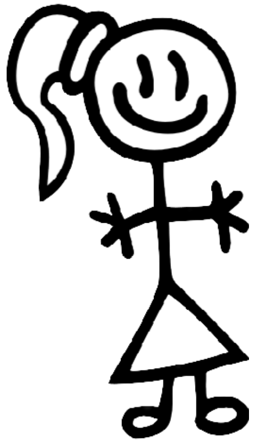

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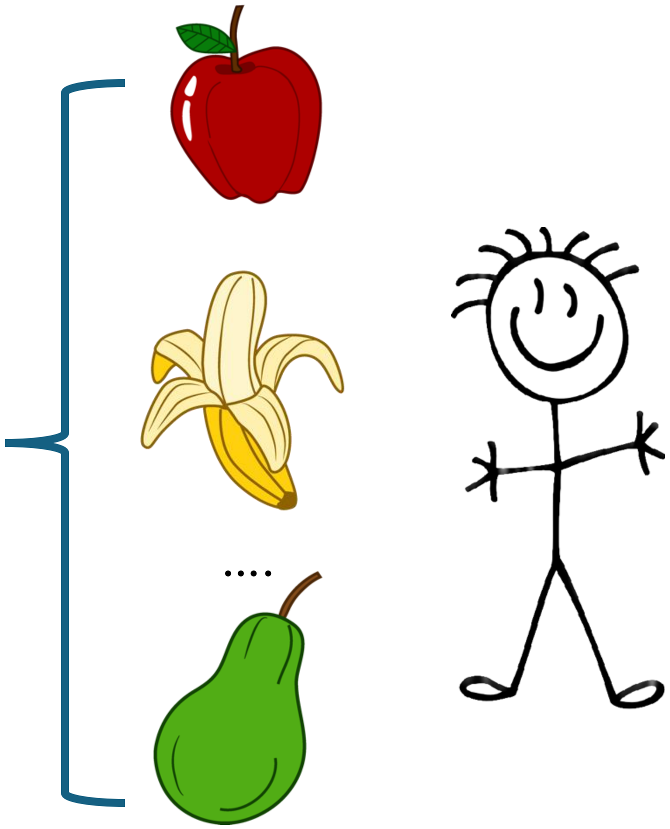

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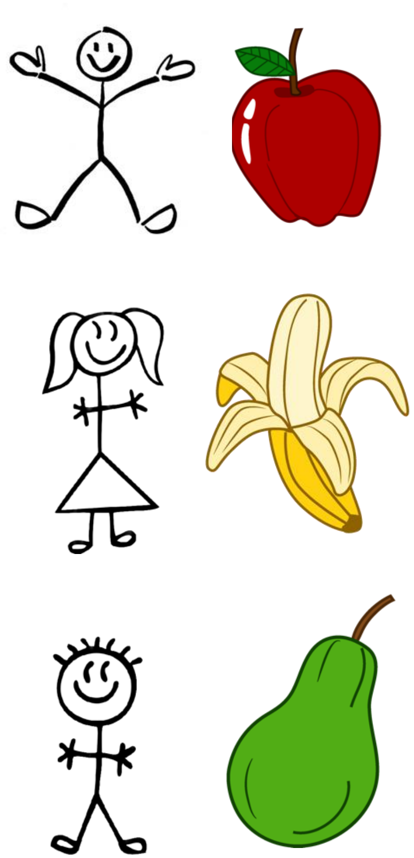
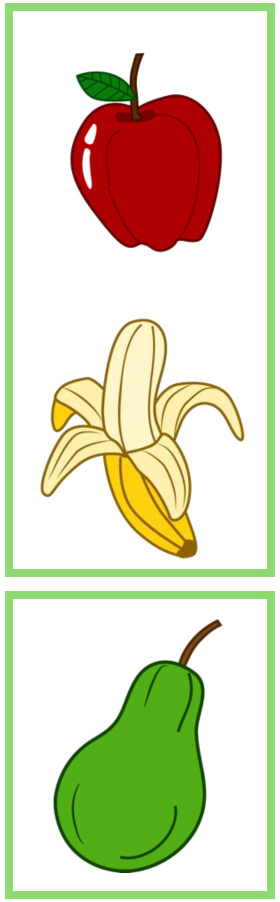
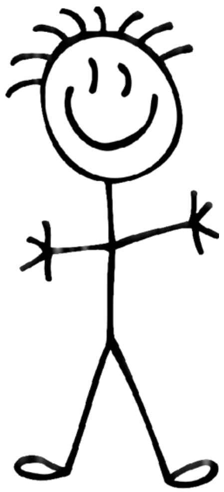


Principal Seller

$7

$3





Principal Seller Commit to a Menu

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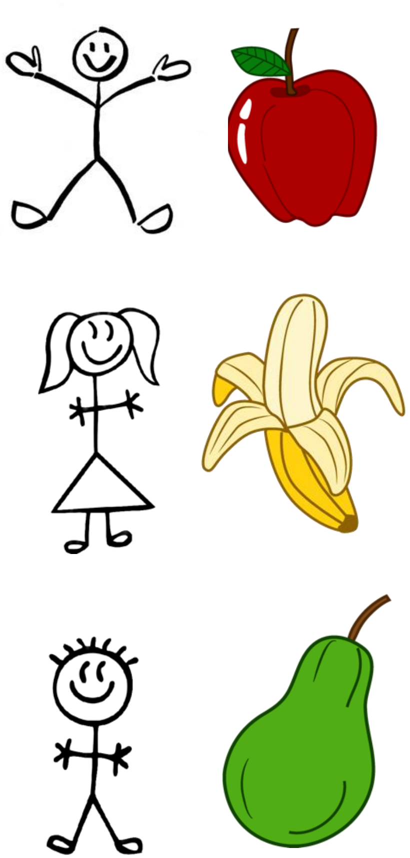

$4

$5

$2

Item Sellers Commit to a (Possibly Mixed) Pricing Strategy

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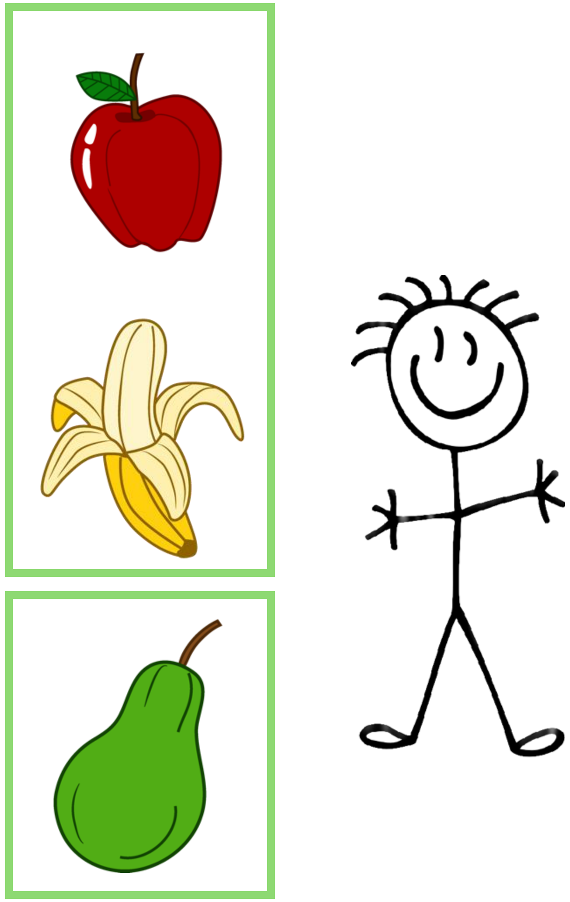

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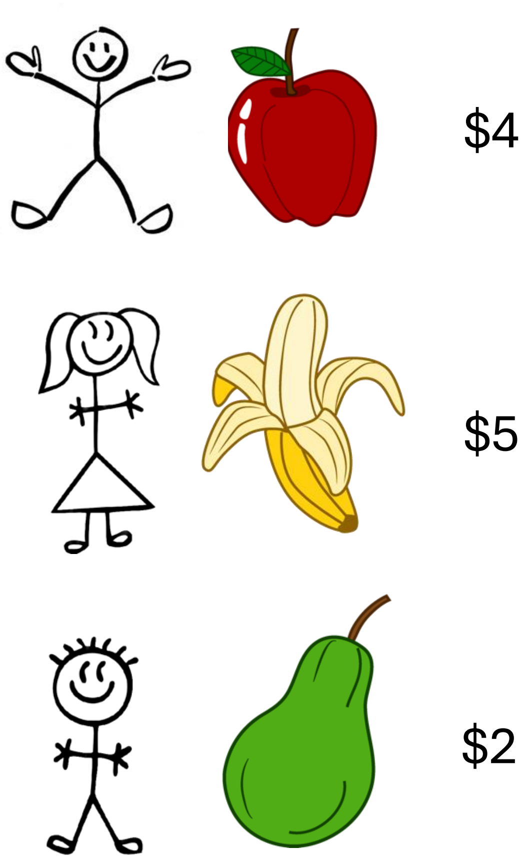

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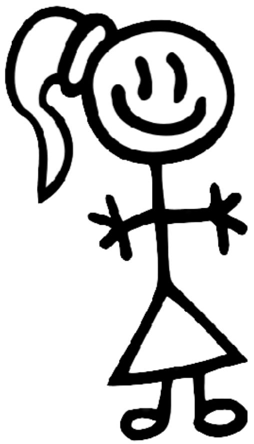

A random buyer (with value drawn from prior distribution) arrives

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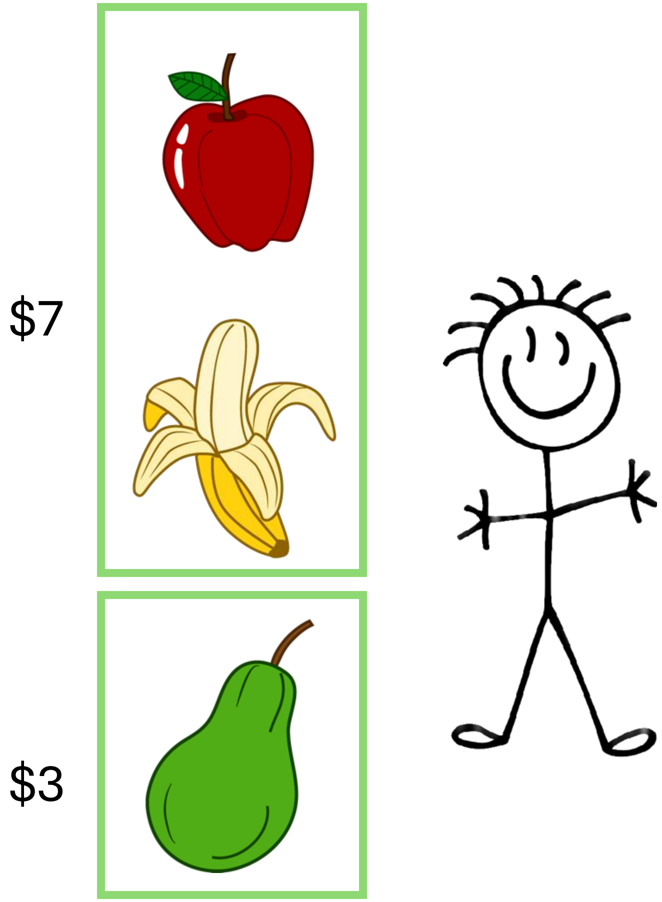

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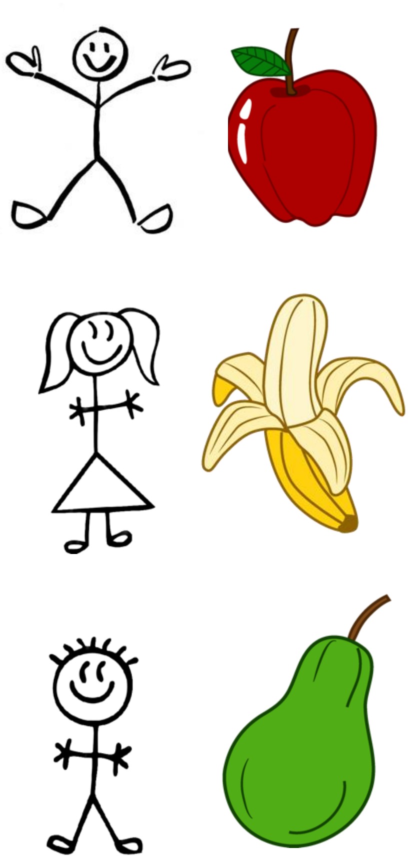

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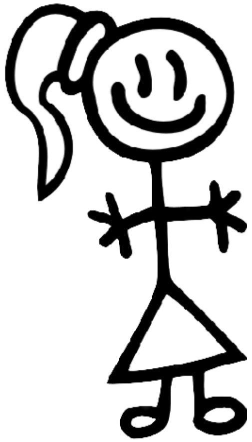

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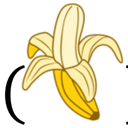
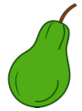
$v($  $) = 6$

$v($  $) = 4$

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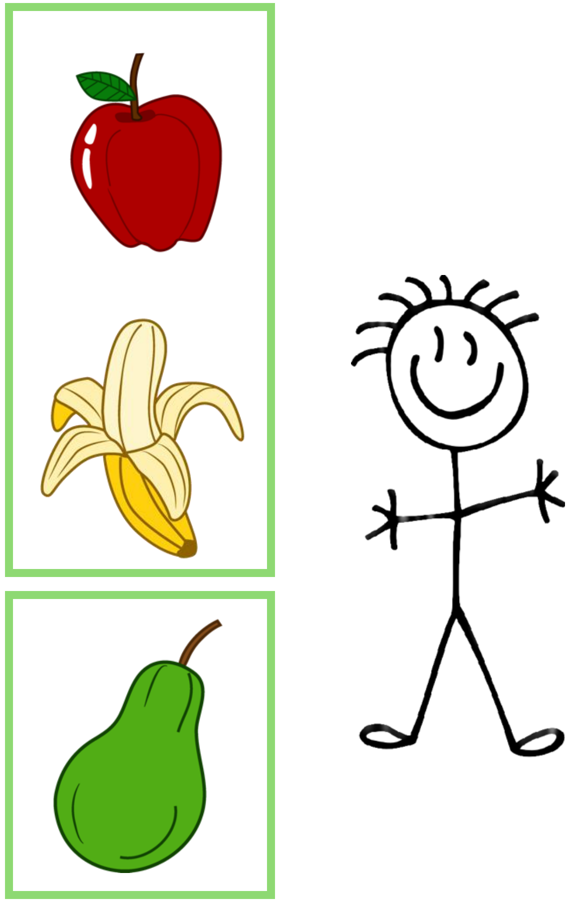

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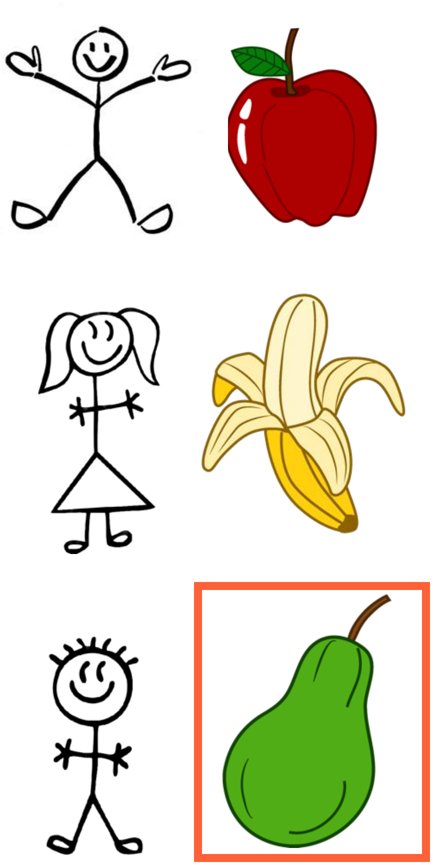

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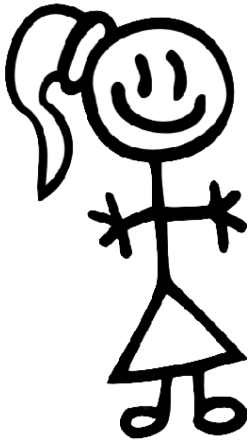

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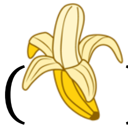
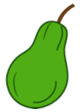
$v($  $) = 6$

$v($  $) = 4$

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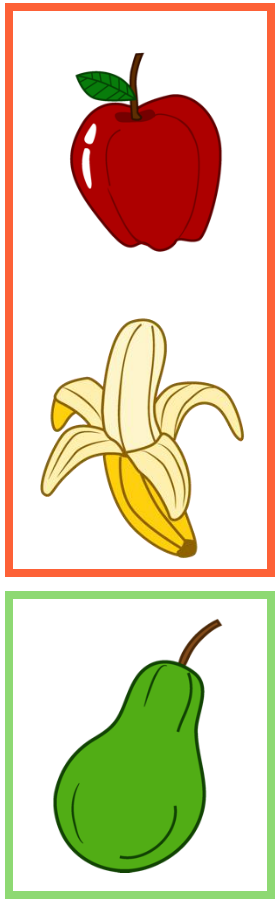

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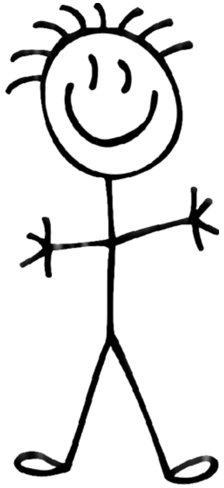

Principal Seller Commit to a Menu

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- **Main Result 1:** We give an upper bound benchmark on the revenue of *any* principal menu.

What menu the principal should choose to maximize revenue?

- **Main Result 2:** (Under assumptions to be described later) We show that *selling the grand bundle* gives the principal a 3-approximation to the optimal revenue.

Revenue Benchmark - Monopolist

Constant Approximation To Optimal Revenue [Babaioff, Immorlica, Lucier, Weinberg]

In any market with a single additive buyer with independent item values,

either selling separately or selling the grand bundle guarantees a 6-approximation to the optimal revenue.

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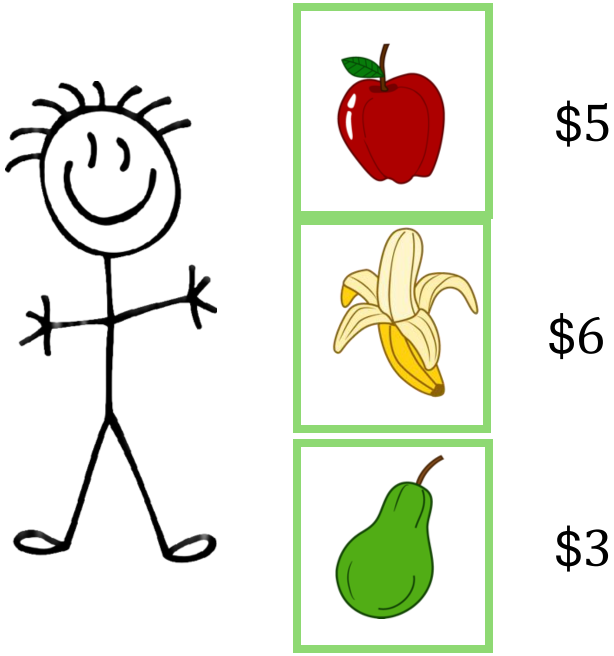

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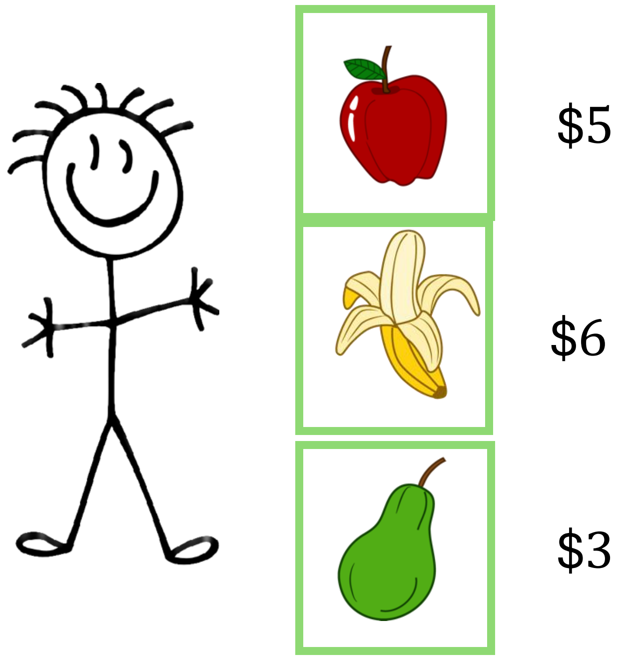

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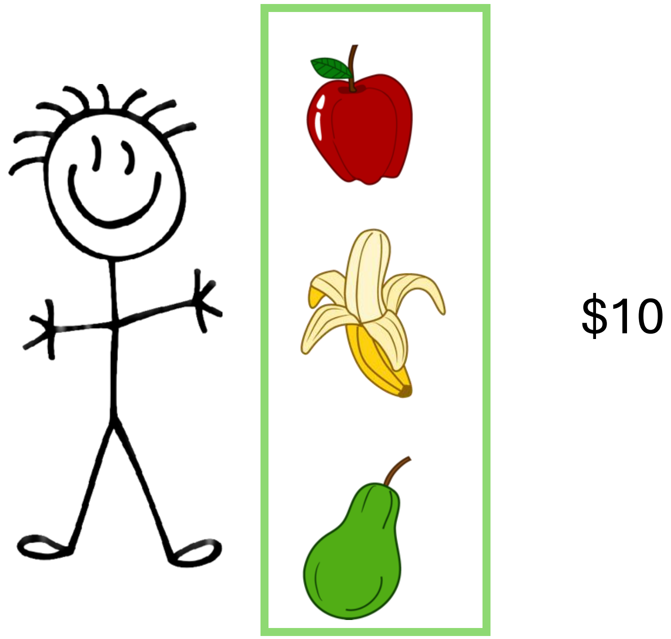
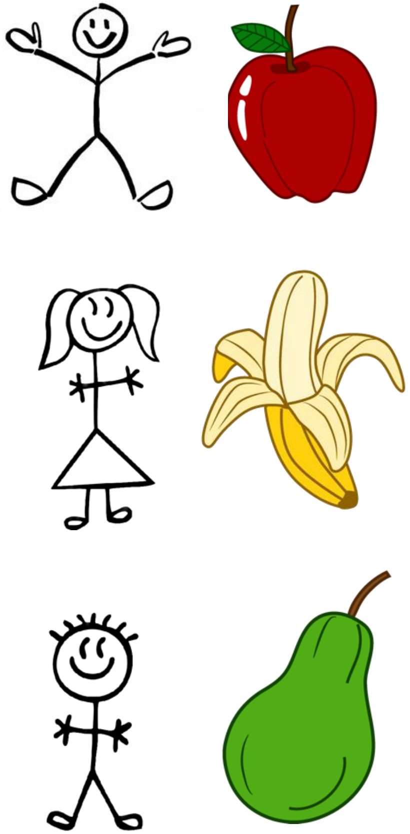
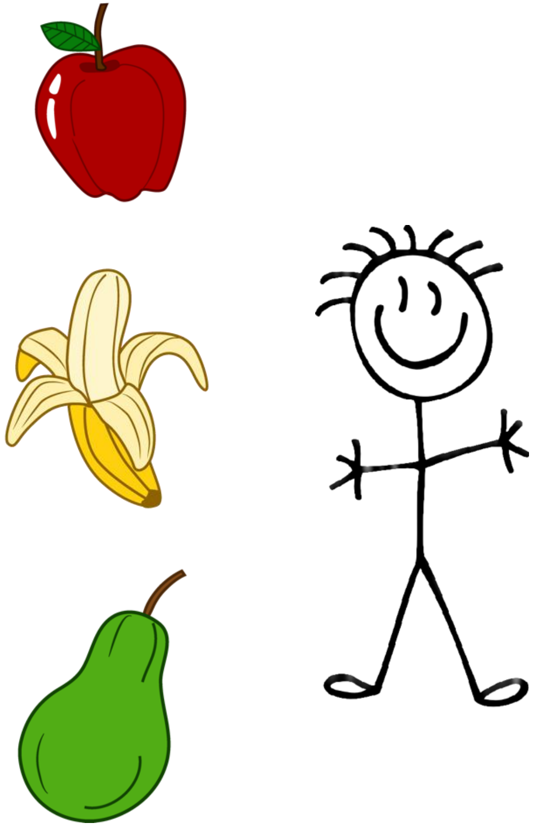


Oligopoly - Selling Separately Yields No Revenue

Single-Item Sellers



Principal Seller



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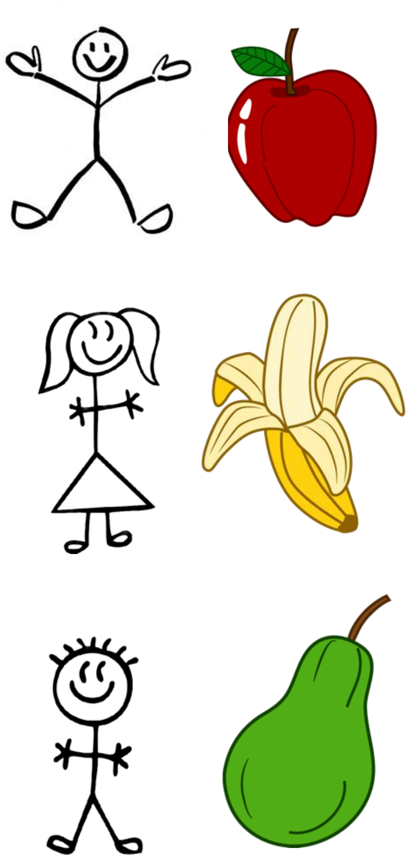
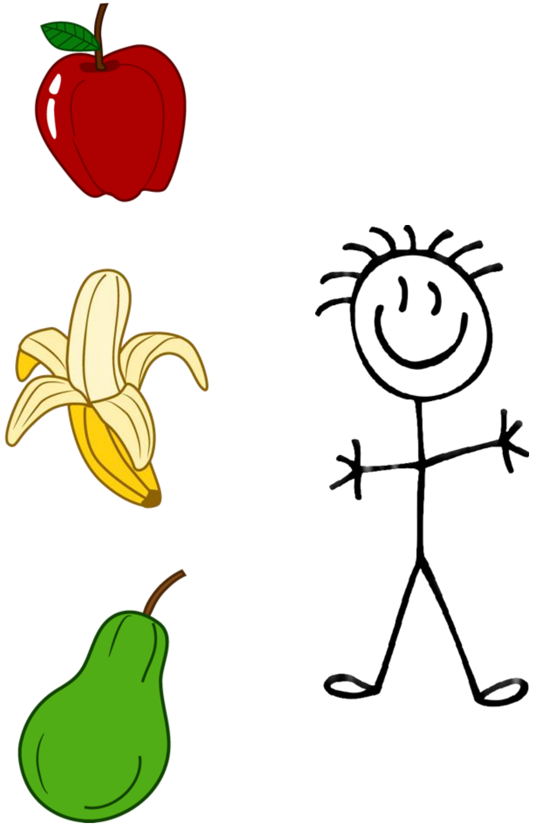


Principal Seller

$5

$6

$3



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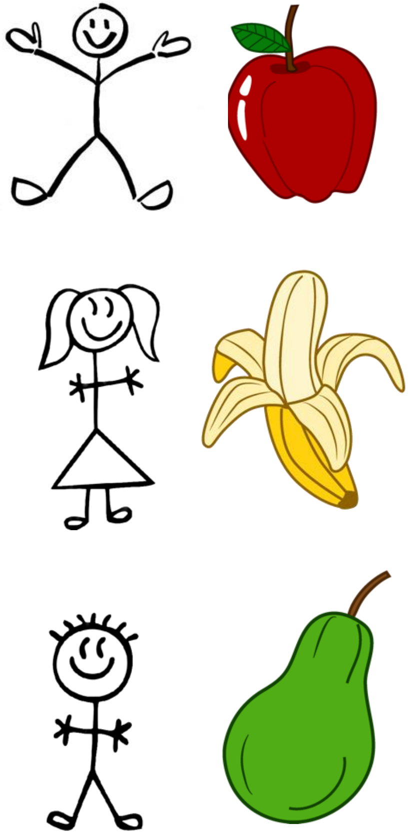

$\$5 - \epsilon$

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Principal Seller

$\$5$

$\$6$

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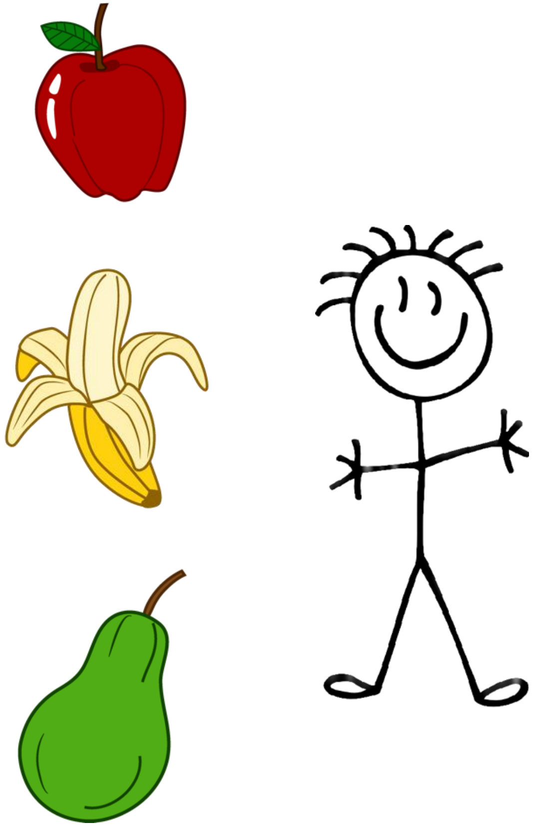

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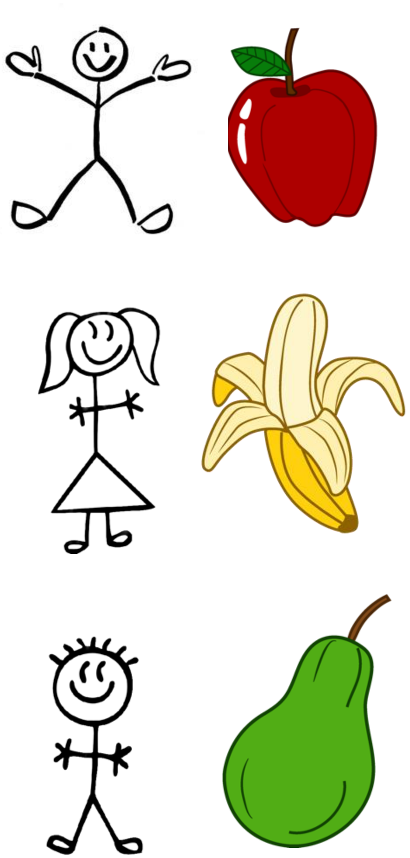

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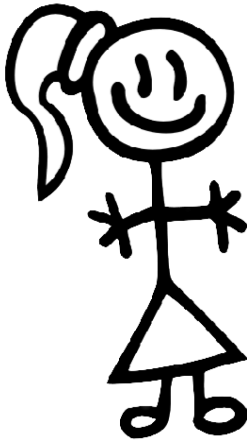
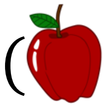


$v($  $) = 6$

$v($  $) = 7$

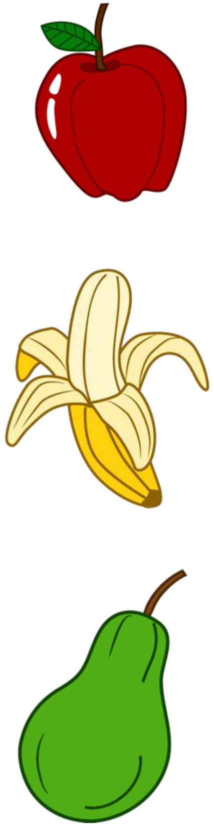
$v($  $) = 2$

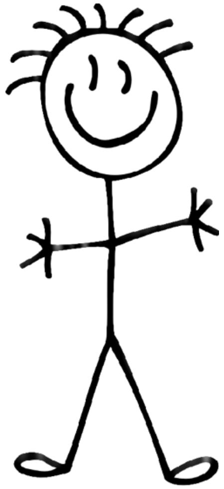
Principal Seller

$\$5$

$\$6$

$\$3$





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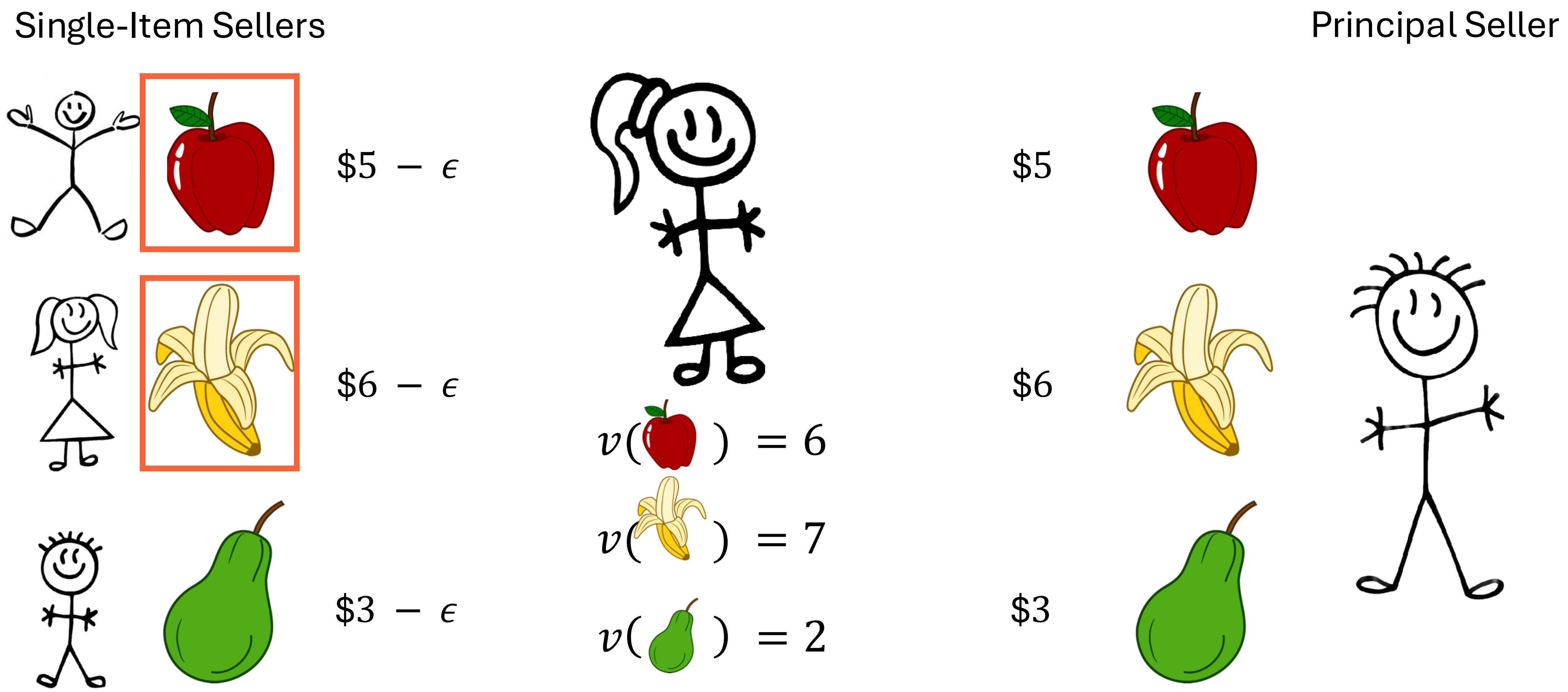

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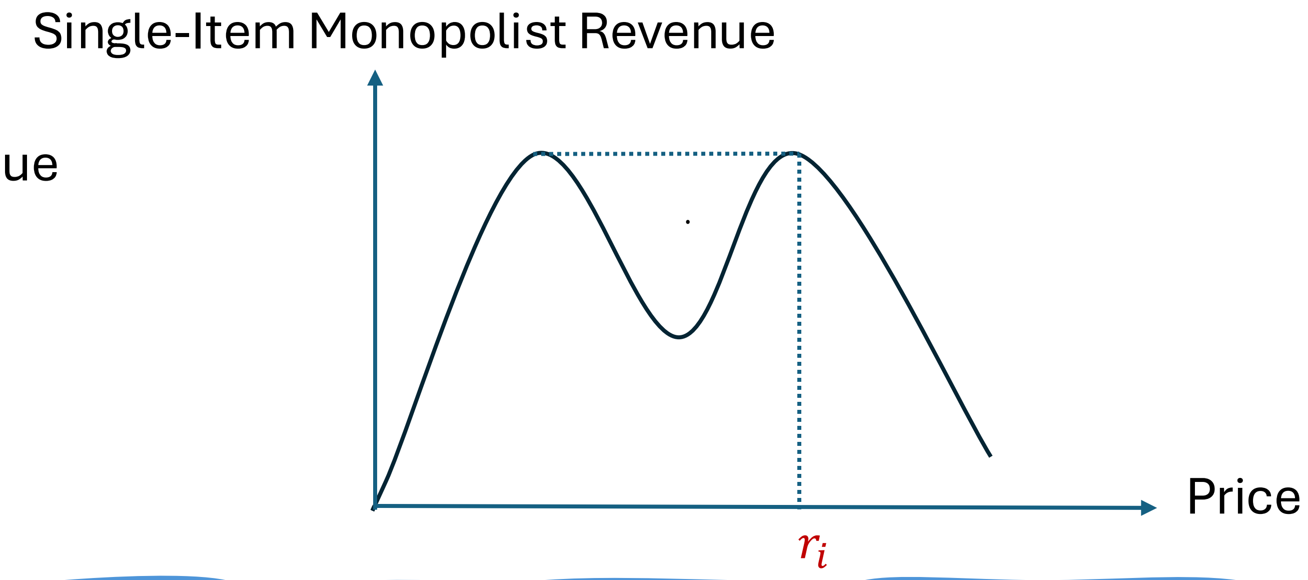
Oligopoly – Revenue Benchmark

For each item i: let r_i be the maximal revenue maximizing price for item i in a monopolist setting



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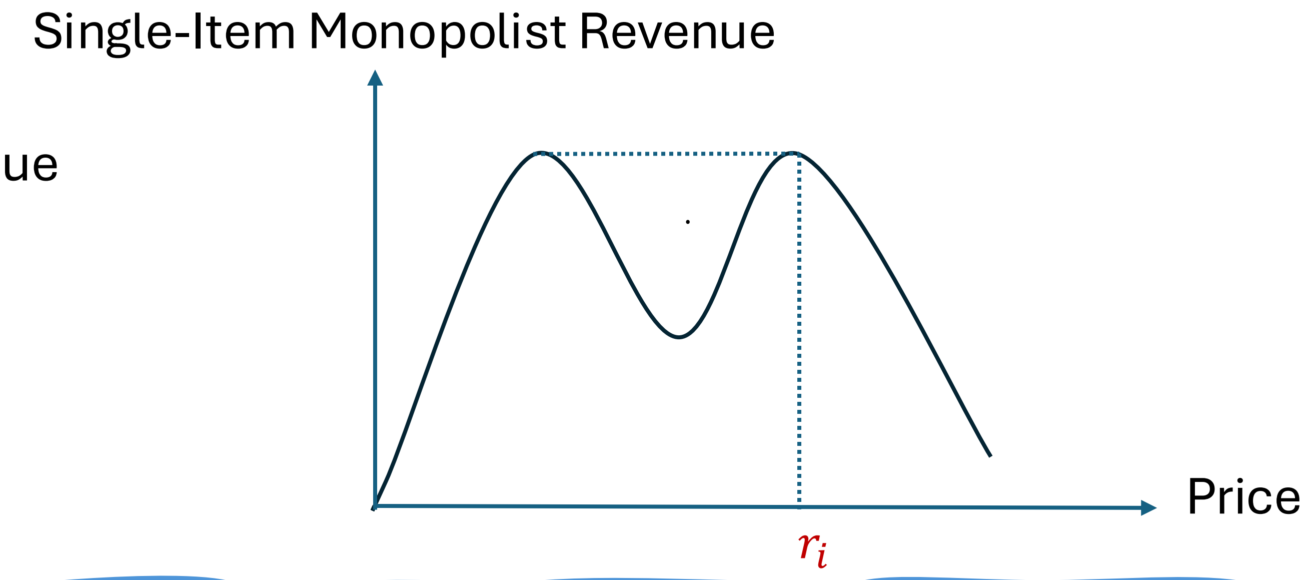

Main Result 1

For ***any*** menu of the principal seller and ***any*** mixed Nash equilibrium among the item sellers, the expected revenue of the principal seller is at most the buyer's expected *truncated social welfare*

$$\mathrm{E}_{v \sim D}\left[\sum_i \min\{v_i, r_i\}\right]$$

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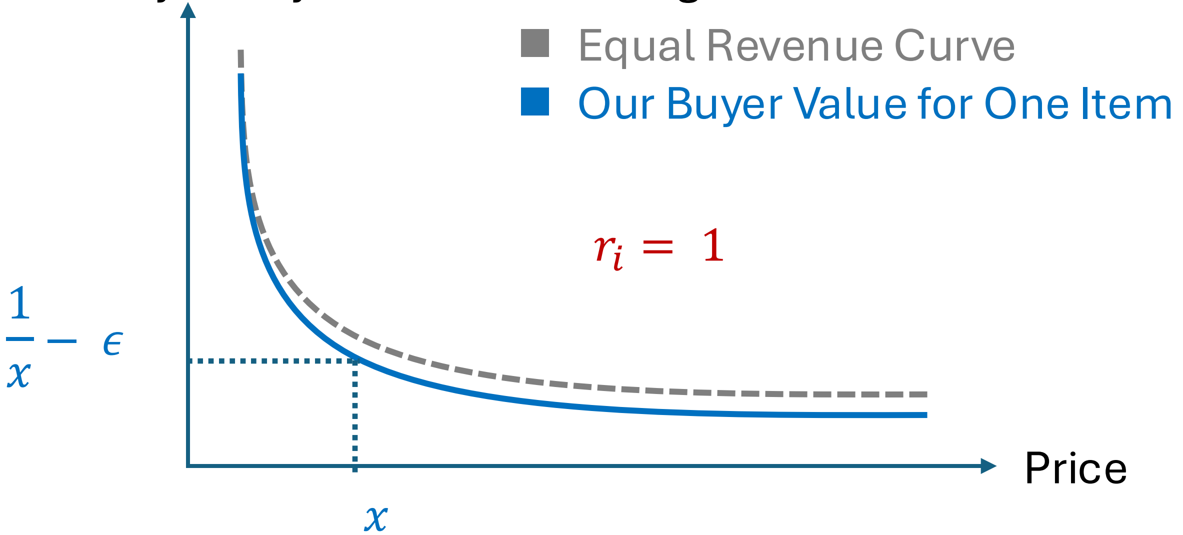

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Optimal Principal Seller Revenue in Our Model	$O(m)$
Optimal Monopolist Revenue	$\Omega(m \log m)$

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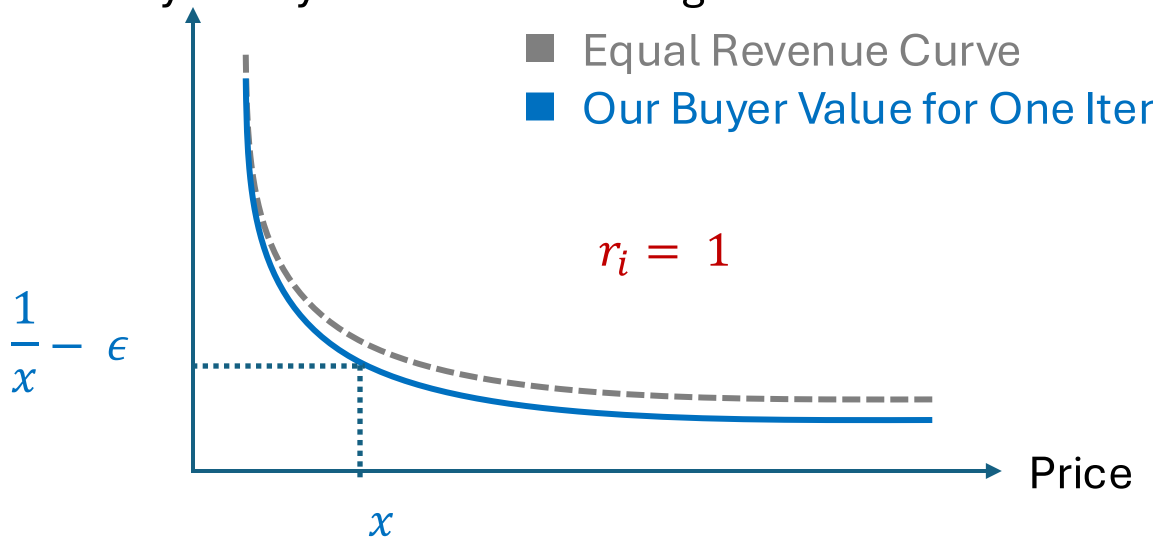

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For each item i: let r_i be the maximal revenue maximizing price for item i in a monopolist setting

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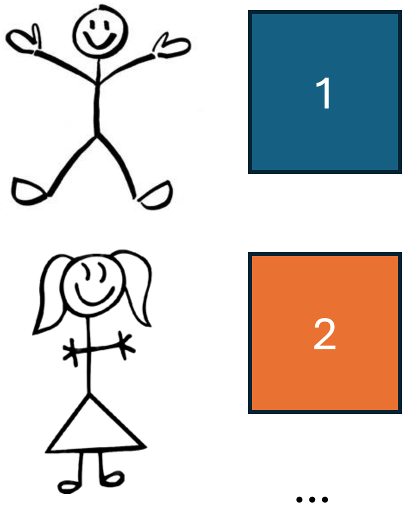
Roughly speaking, we can assume item seller i prices in range $[0, r_i]$ at equilibrium

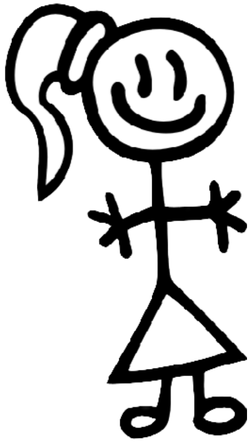
Oligopoly – Revenue Benchmark

$v \sim D = \times_j D_j$

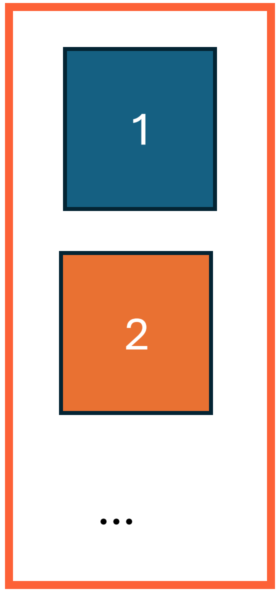


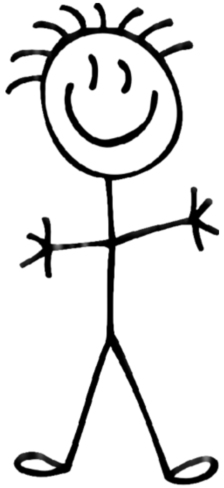
$q_1 \leq r_1$

$q_2 \leq r_2$



Principal Seller





Principal menu price for item set S: $p(S)$

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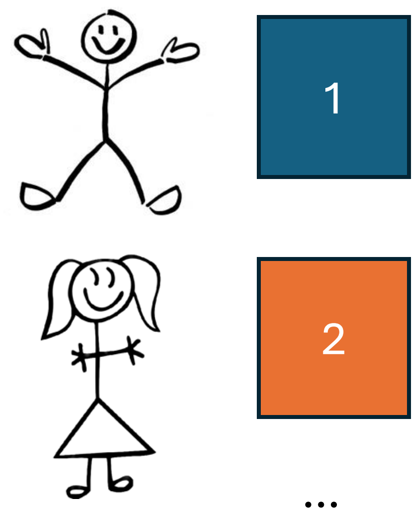

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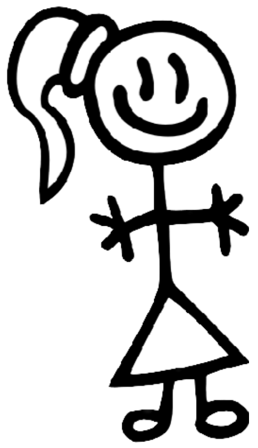

The buyer's "willingness to pay" for item i is at most $\min(v_i, r_i)$

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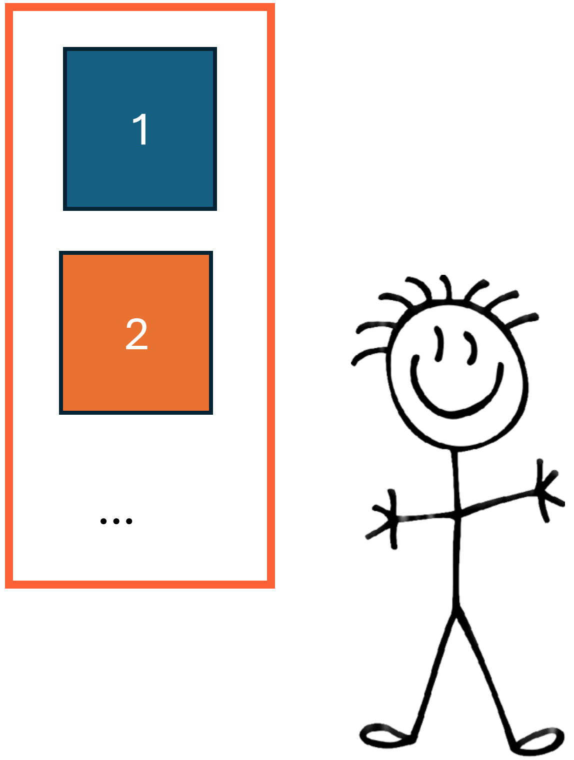

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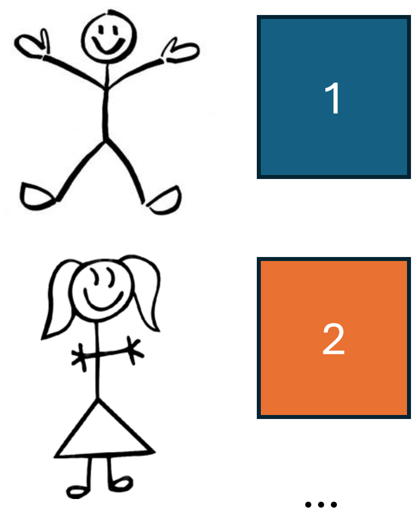

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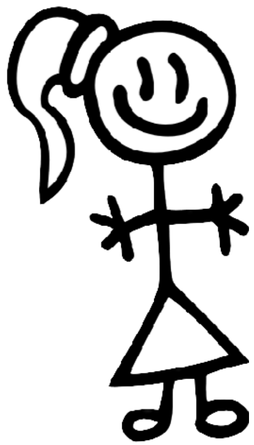

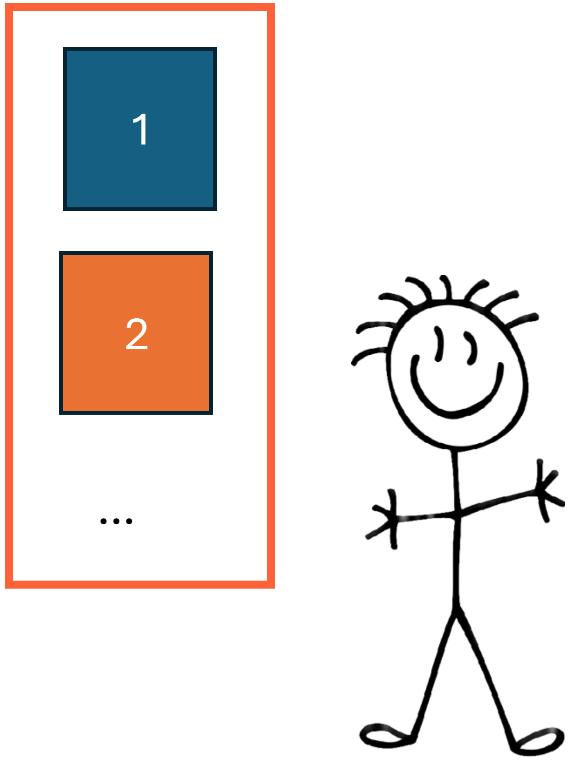

The buyer's "willingness to pay" for item i is at most $\min(v_i, r_i)$

$\Rightarrow$ Principal revenue is upper bounded by *truncated social welfare* $\mathrm{E}_{v \sim D}[\sum_i \min\{v_i, r_i\}]$

Principal menu price for item set S: $p(S)$

When is Bundling Effective?

Main Result 2

Under our assumptions, there exists a price p at which the principal can sell the grand bundle of all items such that, at ***any*** mixed-nash equilibrium for the item sellers, the principal's revenue is at least $1/3$ of the expected truncated social welfare.

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All but one item has value distribution $U[0,1]$
One item has value distribution $U[0,200]$

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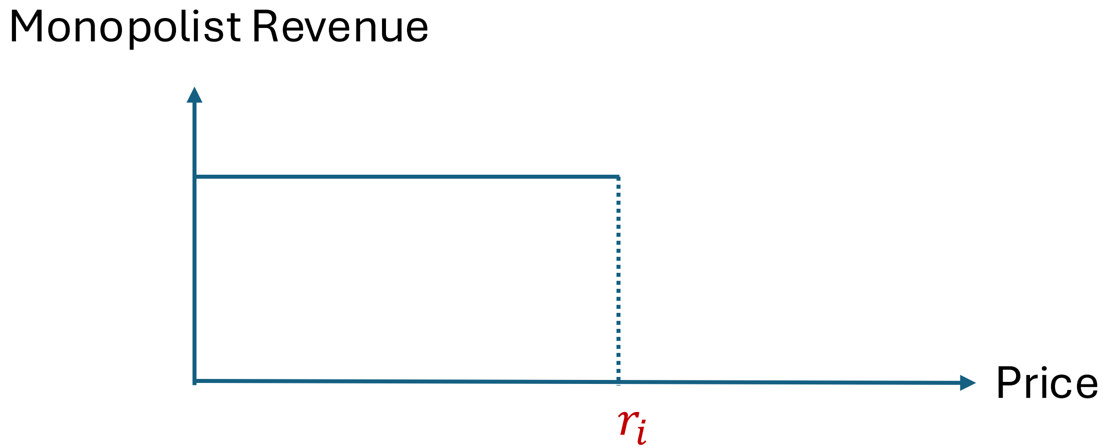

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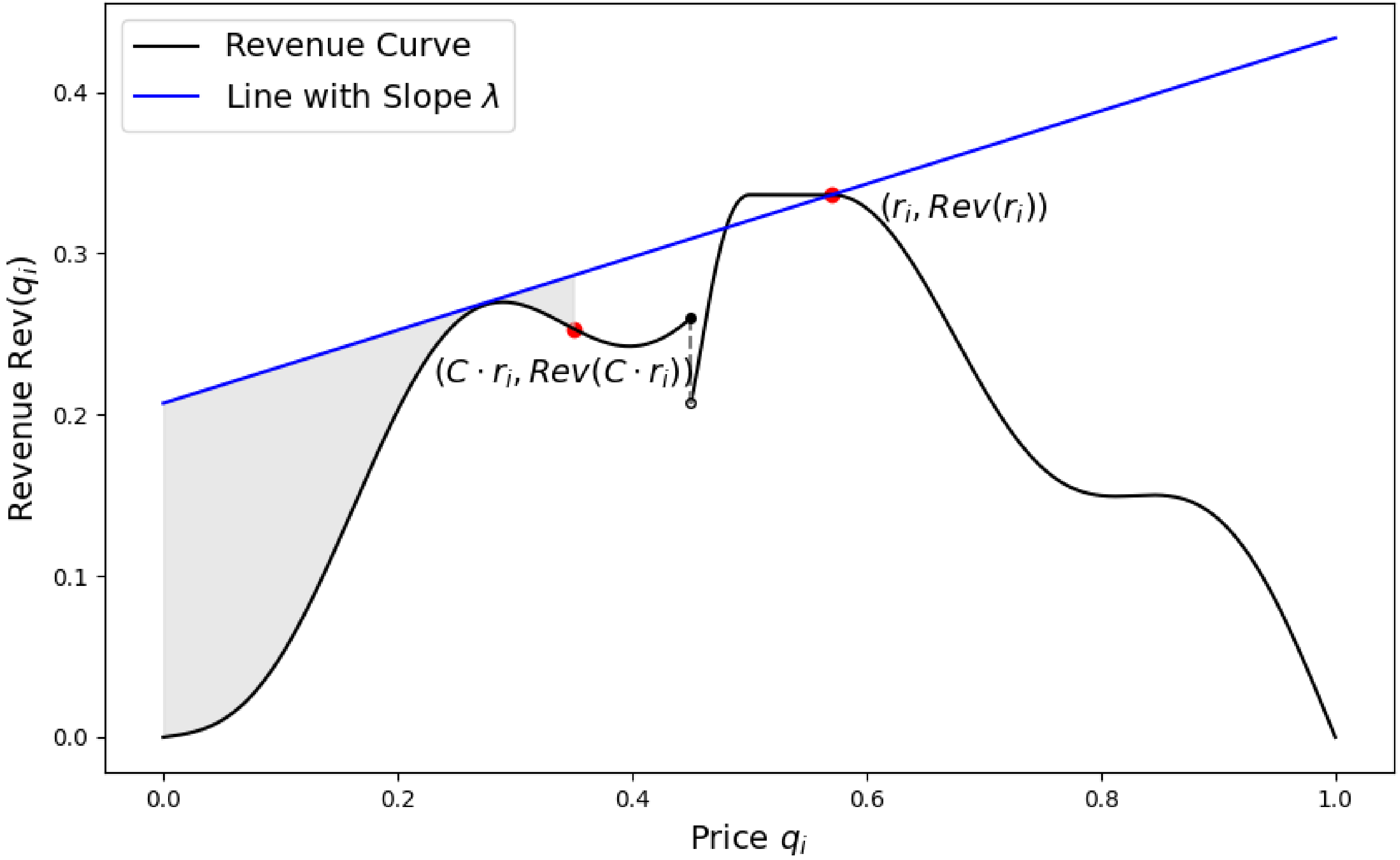

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Note: If only some subset S of the items satisfy our assumptions, then the principal's revenue can approximate the expected truncated welfare of the items in S.

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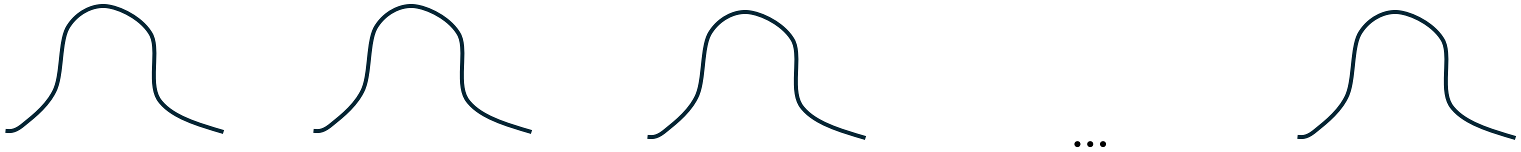

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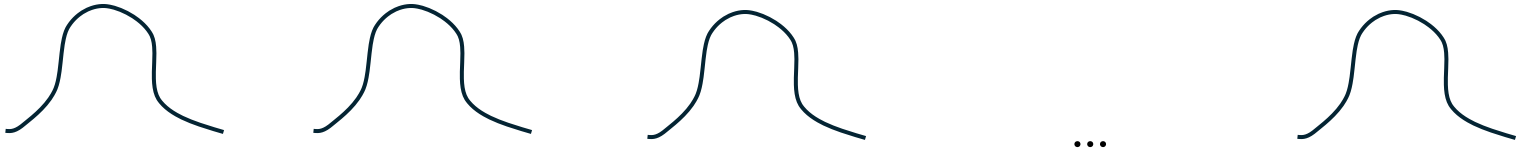

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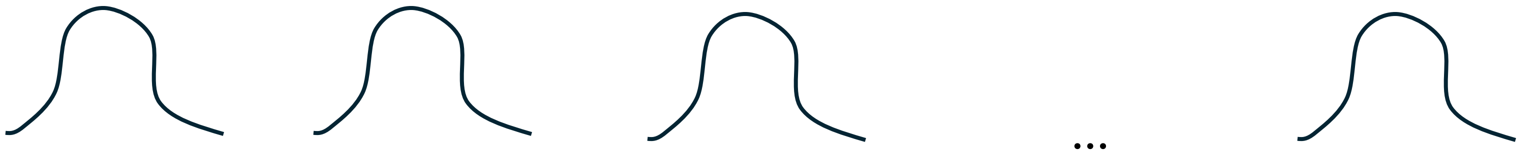

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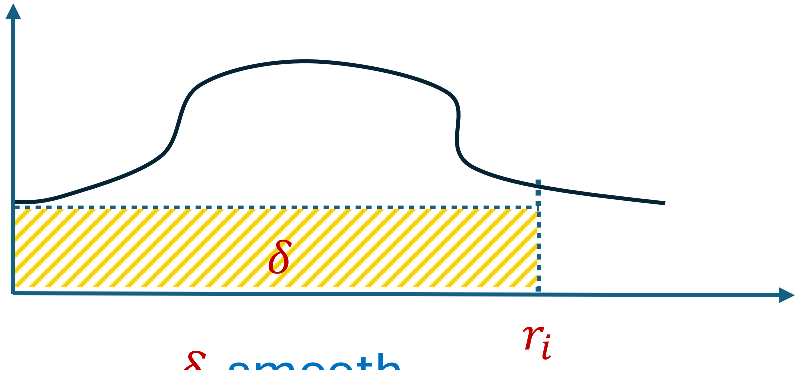

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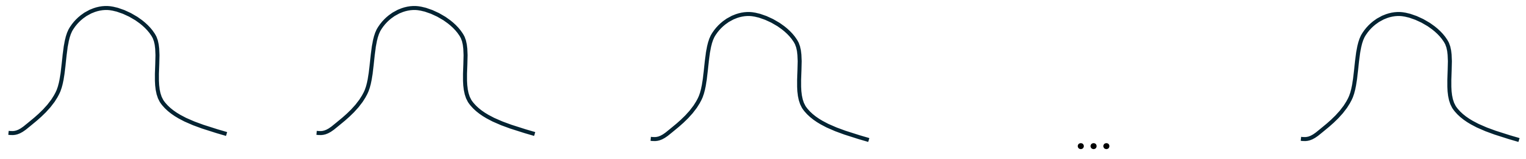

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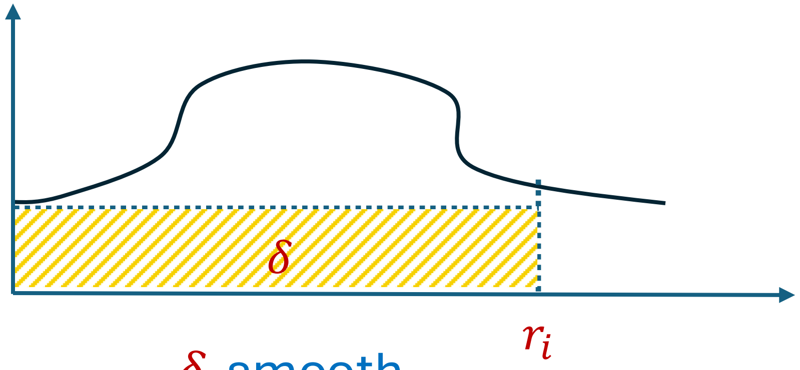
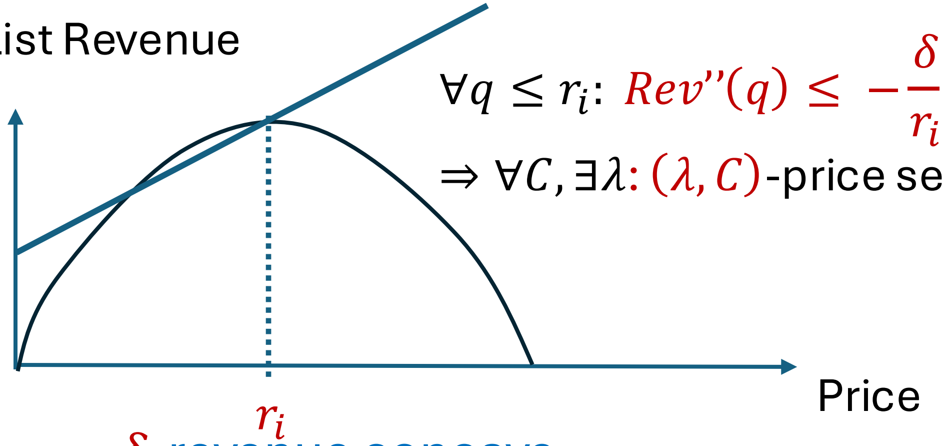


δ-smooth

Monopolist Revenue



$\forall q \le r_i$: $Rev''(q) \le -\frac{\delta}{r_i}$

$\Rightarrow \forall C, \exists \lambda$: (λ, C)-price sensitive

δ-revenue concave

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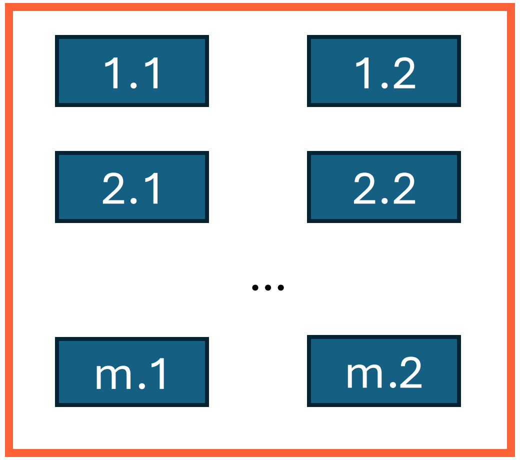
The Grand Bundle



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When our conditions are not met, we construct examples where:

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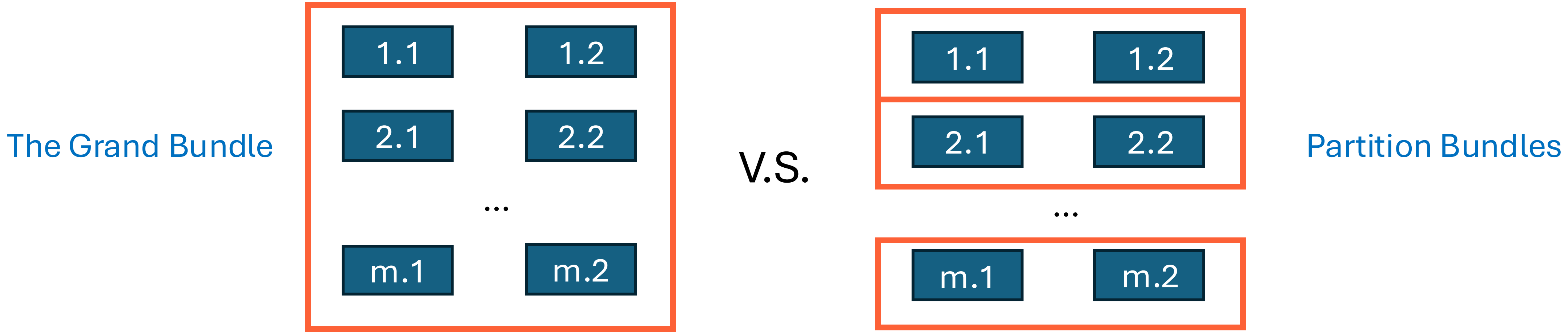
- Principal can obtain $\Omega(m)$ revenue by selling the partition bundles.



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  - Any burning question in your mind!

THANK YOU!

Questions?