Consumer Search and Optimal Pricing under Limited Commitment

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Motivation

Advertised price and actual price are often different

- Physical stores:
  - Furniture and appliance purchase with hidden delivery and installation costs
- Online shopping:
  - Pricewatch.com: $1 for a memory module and $40 shipping and handling fees at check out (Ellison and Ellison, 2009)
  - Airbnb: posted nightly rate does not include cleaning fee
  - Price difference is the major reason that consumers abandon shopping carts after expressing interest in purchasing (Forrester survey, 2009)

This paper

Present a consumer search framework with limited price commitment by the seller

Research Questions

- Market outcome: higher degree of limited commitment enhances market efficiency
- Regulation: stricter regulation could hurt consumers
- Heterogeneity on level of commitment: full commitment brings advantage to a seller but limited commitment does not

Related Literature

Consumer Search:

- Price unobservable: Wolinsky (1986), Anderson & Renault (1999)
- Price observable: Armstrong & Zhou (2011), Shen (2015), Haan, Morage-Gonzalez & Petrikaite (2017), Choi, Dai & Kim (2018)

Add-on pricing:

- Ellison (2005), Gabaix and Laibson (2006), Kosfeld and Schüwer (2017)

Obfuscation:

- Search cost: Ellison and Wolitzky (2008), Wilson (2010)
- Framing: Spiegler (2006), Piccione and Spiegler (2012)

Limited commitment:

- Kim(2009), Bagwell(2018)

Baseline

Regulation

Duopoly

Environment: Seller

One seller posts p, charges p'

Two types of seller

- *Commitment type*: $p' = p$
- *Non-Commitment type*: $p' \perp\!\!\!\perp p$
- Probability of *Commitment type*: $\mu \in (0, 1)$

Seller's type is his private information

Environment: Consumer

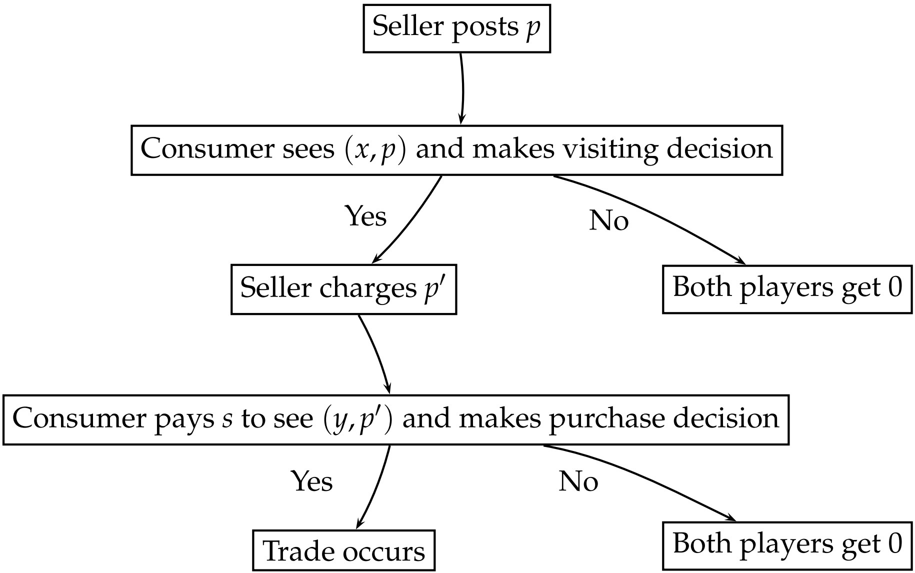
Unit mass of consumers, each with unit demand

- A consumer's value for the product is $x + y$:
  - x: known, drawn according to F (density f)
  - y: hidden, drawn according to G (density g)
  - Both f and g are log-concave
  - x and y: independent of one another, across consumers
- Consumers pay search cost s to see y
- If a consumer with (x, y) purchases from the seller, then the payoff is

$$U = x + y - p' - s$$

- Outside option is normalized to 0

Timing



Seller posts p
Consumer sees (x, p) and makes visiting decision
Yes
No
Seller charges p'
Both players get 0
Consumer pays s to see (y, p') and makes purchase decision
Yes
No
Trade occurs
Both players get 0

Demand

Cutoff rules for consumers

- Visit iff $x \geq x^*(p)$
  - $0 = -s + \mathbb{E}[\int_{-\infty}^{\infty} \max\{0, x^* + y - p'\} dG(y) | p]$
- Purchase iff $x + y - p' \geq 0$

Demand:

$$D(p, p') = \int_{x^*(p)}^{\infty} [1 - G(p' - x)] dF(x)$$

No Commitment ($\mu = 0$)

- Consumers face a hold-up problem
- Equilibrium price p_N satisfies the following condition:
  - Given belief, seller solves $\arg\max_{p'} p' D(p, p')$
  - Belief is correct, $\arg\max_{p'} p' D(p_N, p') = p_N$

Formula

Full Commitment ($\mu = 1$)

- Equilibrium price p_C is obtained by

$$\arg\max_{p} \; pD(p,p)$$

- Compare the case of $\mu = 0$ and $\mu = 1$ yields $p_C \leq p_N$
  - p_C delivers maximal profit but the non-commitment type cannot commit to charge it
- Full commitment power resolves the hold-up problem

Formula

Incomplete Information ($\mu \in (0, 1)$)

- Posted price
  - influences demand and profit directly
  - is also a signaling device
- Two types of equilibrium
  - Separating equilibrium
  - Pooling equilibrium
- Off-path belief: non-commitment type

Separating Equilibrium

Proposition

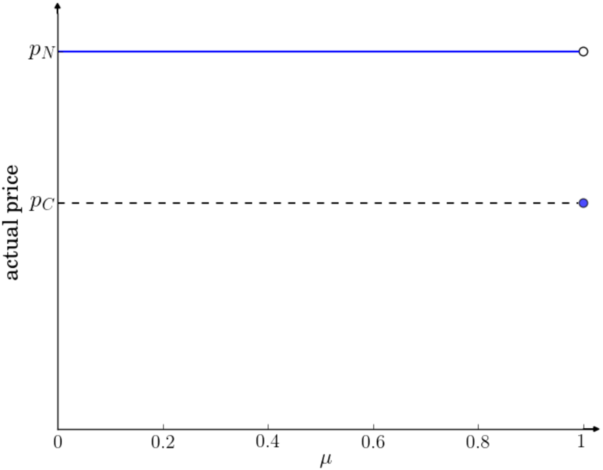
There is a continuum of separating equilibria.
The commitment type posts and charges p_N.
The non-commitment type posts $p \neq p_N$ and charges p_N.

The non-commitment type charges p_N as type is revealed

Why commitment type posts p_N?

- Price lower than p_N is not credible
- Price higher than p_N is less profitable

Separating Equilibrium



- For $\mu \in (0, 1)$, market outcome is equivalent to the case of $\mu = 0$
- More commitment does not help

Pooling Equilibrium

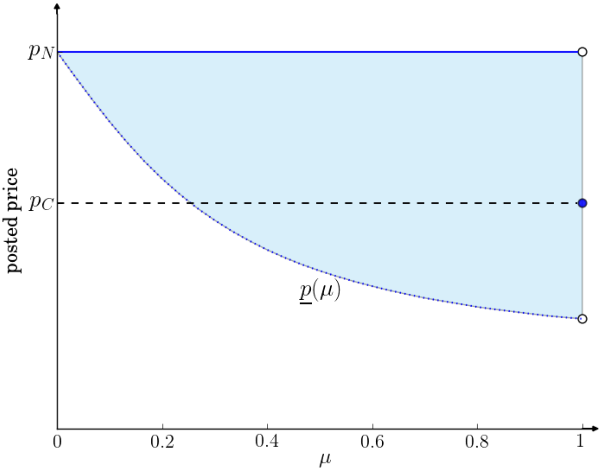
Proposition

There is a continuum of pooling equilibria.
Given μ, there exists $\underline{p}(\mu)$ such that, $\forall p \in [\underline{p}(\mu), p_N]$, there is an equilibrium in which both types of seller post p and the non-commitment type seller charges $\phi_\mu(p) \geq p$.

$\underline{p}(\mu)$ is determined by the commitment type's IC

- Non-commitment type prefers a lower posted price
- Commitment type sticks to the low posted price

Level of Commitment Power



Level of Commitment Power

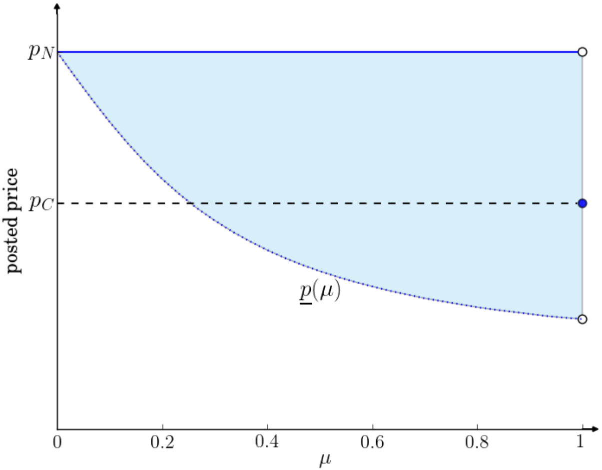
Proposition

$\underline{p}(\mu)$ decreases in μ.

Fix $\underline{p}$, as μ increases, compare equilibrium profit and deviation profit

- Deviation profit stays the same as the case with no commitment
- More likely to meet the commitment type
- $\phi_\mu(\underline{p})$ decreases
- Demand and thus equilibrium profit increases

Implications



- Higher level of limited commitment enhances market efficiency
- Limited commitment may be more desirable to consumers than full commitment

Equilibrium Refinement

Intuitive Criterion by Cho and Kreps (1987)

- Removes at least the lower part of the pooling equilibrium set
- Keeps the separating equilibrium

Undefeated Equilibrium by Mailath, Okuno-Fujiwara and Postlewaite (1993)

- Pareto Efficiency
- Removes the upper part of the pooling equilibrium set
- Eliminates the separating equilibrium

Baseline

Regulation

Duopoly

Regulation

Regulation in practice

- Ebay and Pricewatch.com mandated that shipping fee is less than a category specific amount
- Airbnb sets a maximum cleaning fee for each listing ($613 cleaning fee for a $50 couch)

Regulation: Environment

- In the beginning, the platform provider announces Δ

$$\underbrace{p'}_{Actual\ Price} - \underbrace{p}_{Posted\ Price} \leq \underbrace{\Delta}_{Regulation}$$

- $X = 0$ and $Y \sim U[0,1]$
  - $y^* - \mathbb{E}_\mu(p) < 0$: nobody visits
  - $y^* - \mathbb{E}_\mu(p) \geq 0$: everyone visits
  - y^*: net option value of visiting the seller and learning the value, with $s = \int_{y^*}^{\infty} 1 - G(y)dy$
- $\mu = 0$: $y^* - p_N < 0$
- $\mu = 1$: $y^* - p_C = 0$

Regulation: Complete Information

Full commitment $\Leftrightarrow \Delta = 0$

No commitment

- Weak Regulation ($\Delta > y^*$)
  - Regulation is not effective
- Strict Regulation ($\Delta \leq y^*$)
  - The seller posts p such that $p + \Delta = y^*$ and charges y^*
  - The seller obtains the full commitment case profit

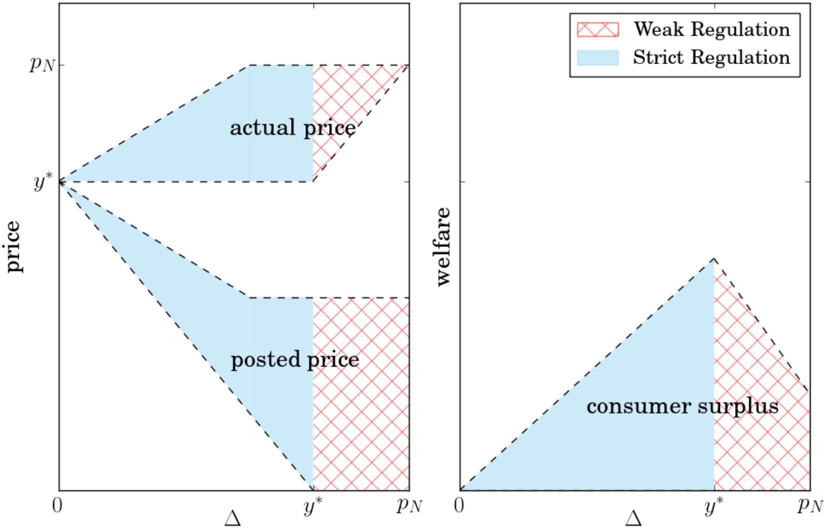
Regulation: Incomplete Information

Regulation provides the seller with a commitment device and mitigates seller's concern of being perceived as a non-commitment type

Most profitable deviation with strict regulation ($\Delta \leq y^*$)

- Non-commitment type: full commitment profit
- Commitment type: posts and charges $y^* - \Delta$
  - Deviation profit increases as Δ decreases

The Effect of Regulation on Pooling Equilibrium



- More regulation can hurt consumers
- Consumer surplus and social welfare are maximized with an intermediate level of regulation

Baseline

Regulation

Duopoly

Duopoly: Environment

- Seller i has probability μ_i to be the commitment type, $i = 1, 2$
- $X = 0$ and $Y \sim U[0, 1]$

Timing:

1. Sellers post prices simultaneously
2. Consumers engage in sequential search with free recall

Duopoly: Complete Information

- If $\mu_1 = \mu_2 = 1$, no pure strategy Nash equilibrium
  - Each seller has incentive to undercut rival's price
  - Different from Bertrand
- If $\mu_1 = \mu_2 = 0$, two types of equilibria
  - symmetric : both sellers charge the same price
  - asymmetric : seller i charges a lower price and thus all consumers visit seller i first
    "Prominence" by Armstrong, Vickers and Zhou (2009)

Duopoly: Complete Information

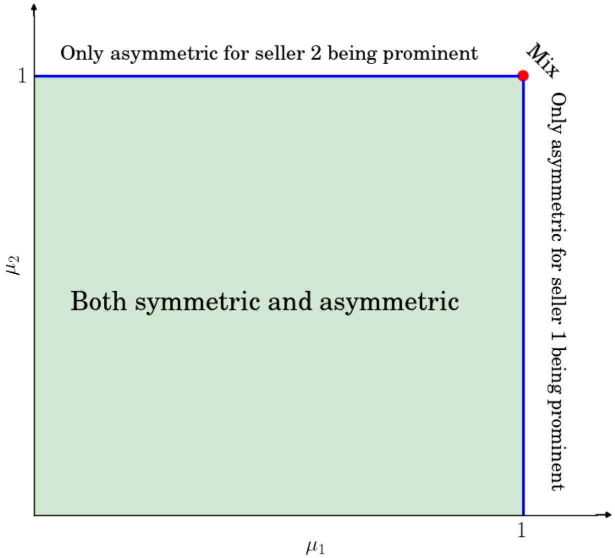
Proposition

If $\mu_1 = 0$ and $\mu_2 = 1$, seller 2 charges a lower price than seller 1.

- The commitment type can undercut the rival
- Full commitment brings prominence

Search Cost
Graph
Welfare

Duopoly: Incomplete Information



Duopoly: Incomplete Information

Proposition

(i) If $0 < \mu_1 < 1$ *and* $\mu_2 = 1$*, in any equilibrium, seller 2 charges a lower price than seller 1.*
(ii) If $0 < \mu_1 < 1$ *and* $0 \leq \mu_2 < 1$*, all equilibria in the case of no commitment remain.*

- Example: $\mu_1 = 99\%$ and $\mu_2 = 1\%$
  $p_1 > p_2$ remains to be an equilibrium

- The seller with limited commitment cannot direct consumers' search

- Limited commitment cannot guarantee prominence

Conclusion

- Build a search model with limited price commitment
  - Unify consumer search models with unobservable price and observable price
- Results
  - Higher level of commitment could enhance market efficiency
  - Stricter regulation could hurt consumers
  - Full commitment brings prominence but limited commitment does not
- Other results in the paper
  - The effect of search cost is non-monotone and depends on the level of commitment and the magnitude of search cost

Search cost

Thank you!

Corner cases prices

No commitment ($\mu = 0$) case equilibrium price:

$$\frac{1}{p_N} = \frac{\int_{p_N - y^*}^{\infty} g(p_N - x) dF(x)}{\int_{p_N - y^*}^{\infty} [1 - G(p_N - x)] dF(x)}$$

Full commitment ($\mu = 1$) case equilibrium price:

$$\frac{1}{p_C} = \frac{[1 - G(y^*)] f(p_C - y^*) + \int_{p_C - y^*}^{\infty} g(p_C - x) dF(x)}{\int_{p_C - y^*}^{\infty} [1 - G(p_C - x)] dF(x)}$$

Back

Duopoly: Search Cost

Proposition

Both p_1 and p_2 increase with search cost s.

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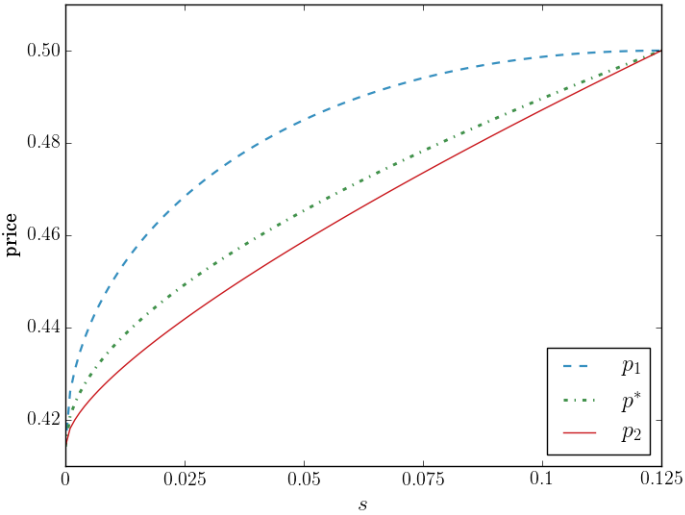
Duopoly



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Duopoly: Welfare

Corollary

Compared to the symmetric benchmark case where both sellers are the non-commitment type, when one seller gains full commitment power,
(i) welfare and consumer surplus are reduced.
(ii) the commitment type seller gains more profit than in the symmetric case while the non-commitment type seller gains less profit than in the symmetric case.
(iii) whether industry profit increases or decreases depends on the magnitude of search cost.

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The Effect of Search Cost: s

$\mu = 0$: $p_N \nearrow s$

- Hold-up effect
- Wolinsky (1986); Anderson and Renault (1999)

$\mu = 1$: $p_C \searrow s$

- Directed search effect
- Armstrong and Zhou (2011); Choi, Dai and Kim (2017)

The Effect of Search Cost: s

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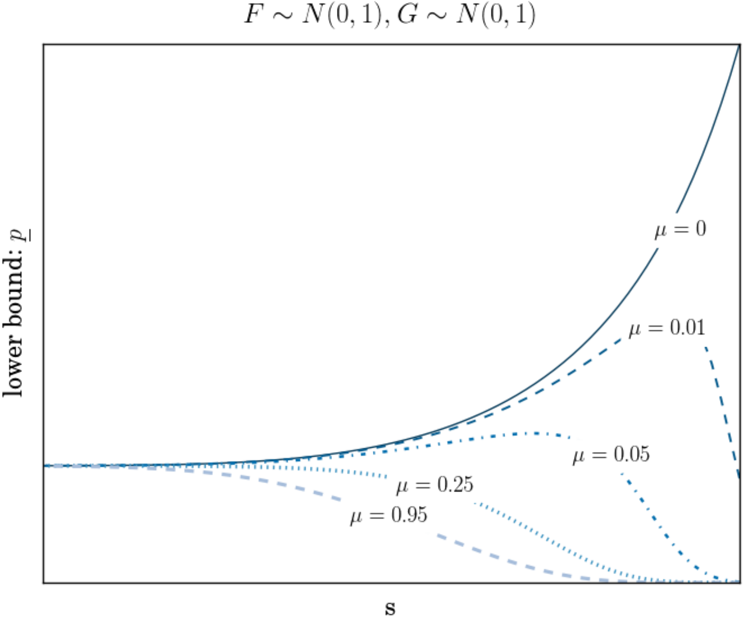
$$\mu \in (0, 1) \ ?$$

$p_N \nearrow s$

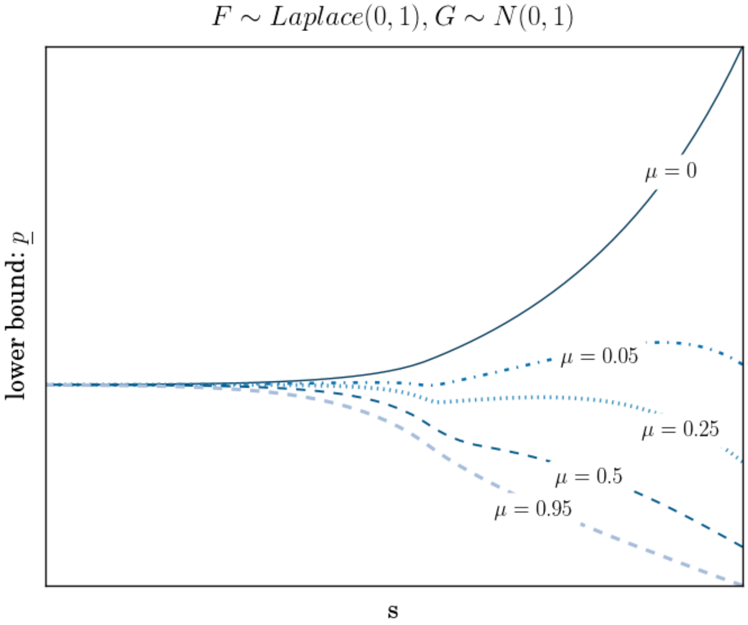
- Separating equilibrium
- Upper bound of pooling equilibrium

How does the lower bound of pooling equilibrium $\underline{p}$ change?

The Effect of Search Cost: s



The Effect of Search Cost: *s*



The Effect of Search Cost: s

$\underline{p}$: the price that makes the commitment type seller indifferent

- deviation profit $\searrow s$

$$\pi_N = p_N \int_{p_N - y^*}^{\infty} [1 - G(p_N - x)] dF(x)$$

- equilibrium profit $\searrow s$

$$\pi_{PC}(\underline{p}) = \underline{p} \int_{\mu \underline{p} + (1-\mu)\phi_\mu(\underline{p}) - y^*}^{\infty} [1 - G(\underline{p} - x)] dF(x)$$

Which profit decreases faster?

The Effect of Search Cost: s

1. $\mu \to 1$
2. $\mu \to 0$
3. $s \to 0$
4. $s \to \infty$

The Effect of Search Cost: s

1. $\mu \to 1$
2. $\mu \to 0$
3. $s \to 0$
4. $s \to \infty$

The Effect of Search Cost: s

1. $\mu \to 1$
2.

- deviation profit $\searrow s$
  - direct search cost effect
  - indirect hold-up effect
- equilibrium profit $\searrow s$
  - direct search cost effect
  - ~~indirect hold-up effect~~
- Deviation profit decreases faster
  $\Rightarrow$ $\underline{p} \searrow s$

The Effect of Search Cost: s

1.
2. $\mu \to 0$

- deviation profit $\searrow s$
  - direct search cost effect
  - indirect hold-up effect
- equilibrium profit $\searrow s$
  - direct search cost effect
  - indirect hold-up effect
  - When p_N is the expected price, charge p_N is optimal
- Equilibrium profit decreases faster $\Rightarrow \underline{p} \nearrow s$

More Search Cost Back

The Effect of Search Cost: s

1.
2.
3. $s \to 0$
4.

- deviation profit $\searrow s$
  - direct effect of search cost
  - indirect hold-up effect
- equilibrium profit $\searrow s$
  - direct effect of search cost
  - indirect hold-up effect
- Deviation profit & Equilibrium profit decrease at same pace
  $\Rightarrow \underline{p} \to s$

The Effect of Search Cost: s

1.
2.
3.
4. $s \to \infty$

- deviation profit $\searrow s$
  - direct effect of search cost
  - indirect hold-up effect
- equilibrium profit $\searrow s$
  - direct effect of search cost
  - indirect hold-up effect
- Deviation profit decreases faster $\Rightarrow \underline{p} \searrow s$

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