No Such Thing As a Free App:
The Freemium Business Model in Digital Applications

Anna-Maria Kyritsaki,
University of Copenhagen
CRETE July 2026, Ios

1. Introduction

- “Freemium”

“Free”

- Restricted version (α features)
- Free users’ tier
- Free applications’ marketplace

“Premium”

- Full version
- Premium users’ tier
- Premium applications’ marketplace

- Successful examples:

1. Introduction

- Efficient market
- Perfect information
- Absence of network externalities
- & rational individuals

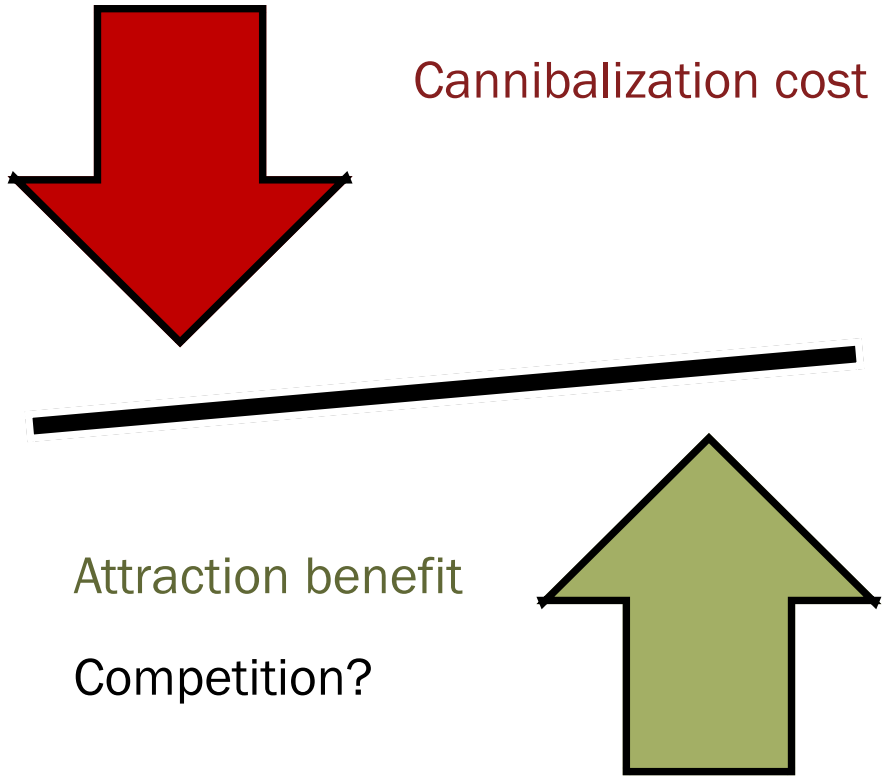
⇒ No free offering in equilibrium

Q1: Why do *high-quality* free offerings exist?

Q2: How does Freemium affect Competition? Can a free product be the source of market power?

1. Introduction

- Why do high-quality free apps exist?
  - *to attract traffic in the premium app*
  - ↑ *quality* ⇒ ↑ *traffic*
- Where's the trade-off?
  - *they cannibalize premium sales*
  - ↑ *quality* ⇒ ↓ *conversion rate*



Main Results

- **Monopoly**

Freemium as a **market solution to a market imperfection**, it improves both Consumer Surplus and firm's profits (shifting more of the additional surplus to consumers)

More efficient than eliminating the information altogether!

- **Duopoly**

Depends on whether it can be used to **lock-in users** or not (learning externalities):
Do users learn about competitors' apps by using a freemium?

- With Learning Externalities:
  increases total CS and profits, intensified competition
- Without Learning Externalities:
  amgibuous effect on CS (some consumers may lose), ambiguous effect on competition (No Bertrand Paradox)

2. Literature Review

- **Versioning & Quality degradation:**

Firms may give degraded versions of their products to screen consumers (Mussa and Rosen (1978), Shapiro and Varian (1999), Deneckere and McAfee (1996))

This paper: zero price, acquisition tool, competition effect

- **Consumer Learning:**

Free access as a way to overcome information frictions. Information asymmetry can distort markets (Nelson (1970), Akerlof (1970)), free access can help consumers learn the quality

This paper: learning about this product (awareness) but may also affect learning about the rival's

2. Literature Review

- **Platform Economics and Network Effects**

Parker and Van Alstyne (2005), Rochet and Tirole (2003), Armstrong (2006), and Caillaud and Jullien (2003) show how cross-side externalities and platform participation can rationalize subsidizing or giving away access to one side of a market

This paper: network effects not needed for zero price to be part of an optimal pricing structure

- **Captive Consumers, Lock-In effects, Soft competition**

Klemperer (1987, 1995) shows that when consumers are locked in, firms may price less aggressively because they can extract surplus from captive buyers.

This paper: lock in effects can be the implicit source of market power that stems from a “freely” offered product

2. Literature Review

- Empirical studies [1],[2] have identified 4 main effects:
  - *The acceleration effect*
  - *The cannibalization effect*
  - *The expansion effect*
  - *The competitive effect*
- Crucial success factor [3], [4], [5] **Quality of the Freemium:**
  - *Too compelling: high traffic, low conversion rate*
  - *Not enough: low traffic, high conversion rate*

3. Model

- Profit Maximizing firm(s)
- One good: digital application
  - *Premium Quality: normalized to 1*
  - *Free App Quality: 1 - α*
- No marginal cost
- Unitary demand
- Two groups of consumers [next slide]
- Outside utility: zero

3. Consumers

Group 1: “Experts”, share λ

- Taste parameters $\theta \sim \mathrm{U}[0,1]$
- Fully informed

3.1 Monopoly

- **No Freemium**
  - Firm can only approach experts, λ
  - Profits

$$\Pi_{NF}^{m} = \begin{cases} \lambda(1-p)p, & if\ p \in [0,1] \\ 0, & otherwise \end{cases}$$

- **Freemium**
  - Can now approach naïve, 1-λ
  - Algorithm: favors higher quality apps

$$g(a) = 1 - a$$

- Stage 1: Firm chooses free app's quality, $1 - \alpha$
- Stage 2: Firm chooses premium app's price, p

$$\Pi_{F}^{m} = \begin{cases} \left(\lambda + g(a)(1-\lambda)\right)\left(1 - \frac{p}{\alpha}\right)p, & if\ p \in [0,a] \\ 0, & otherwise \end{cases}$$

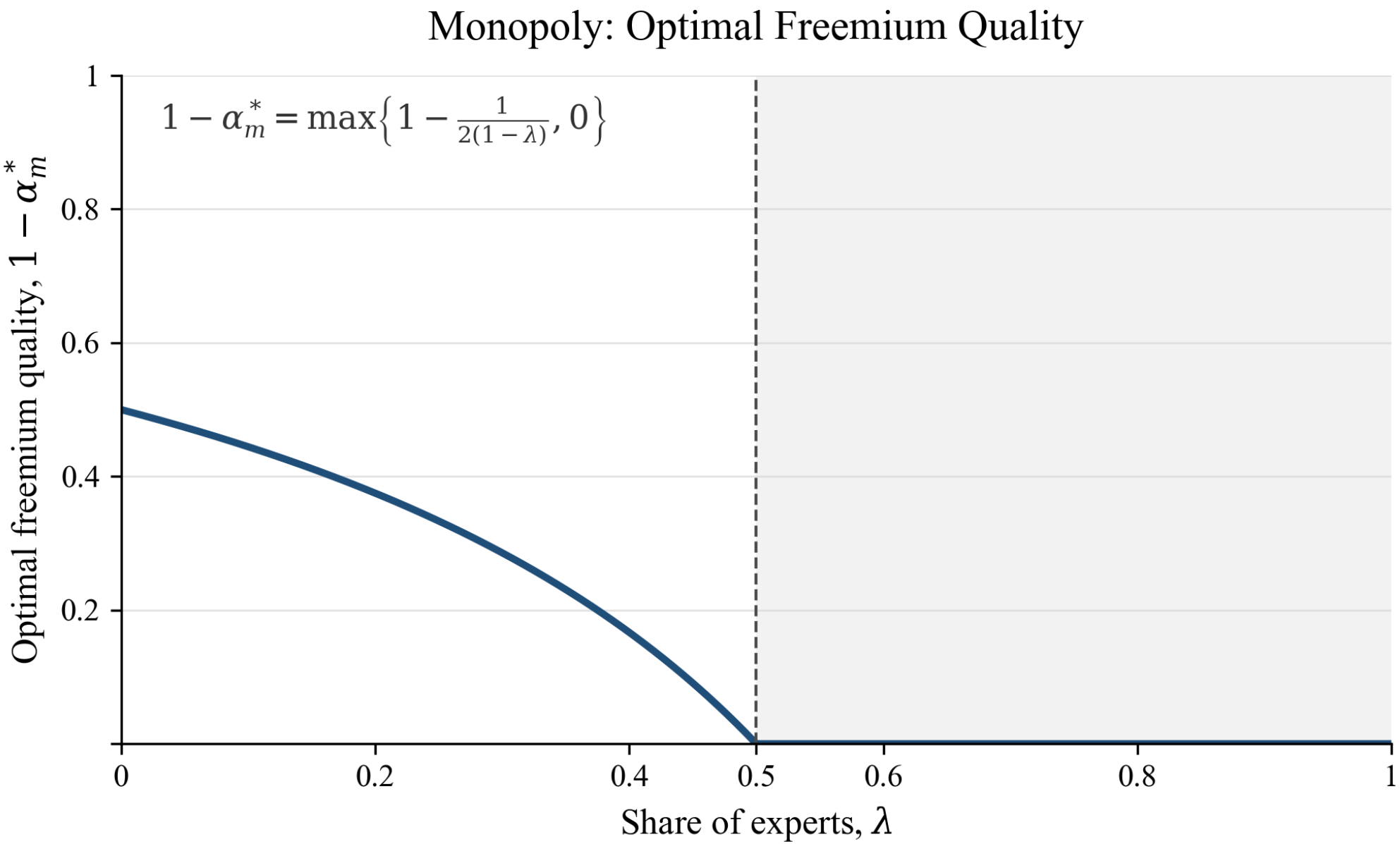
attraction effect

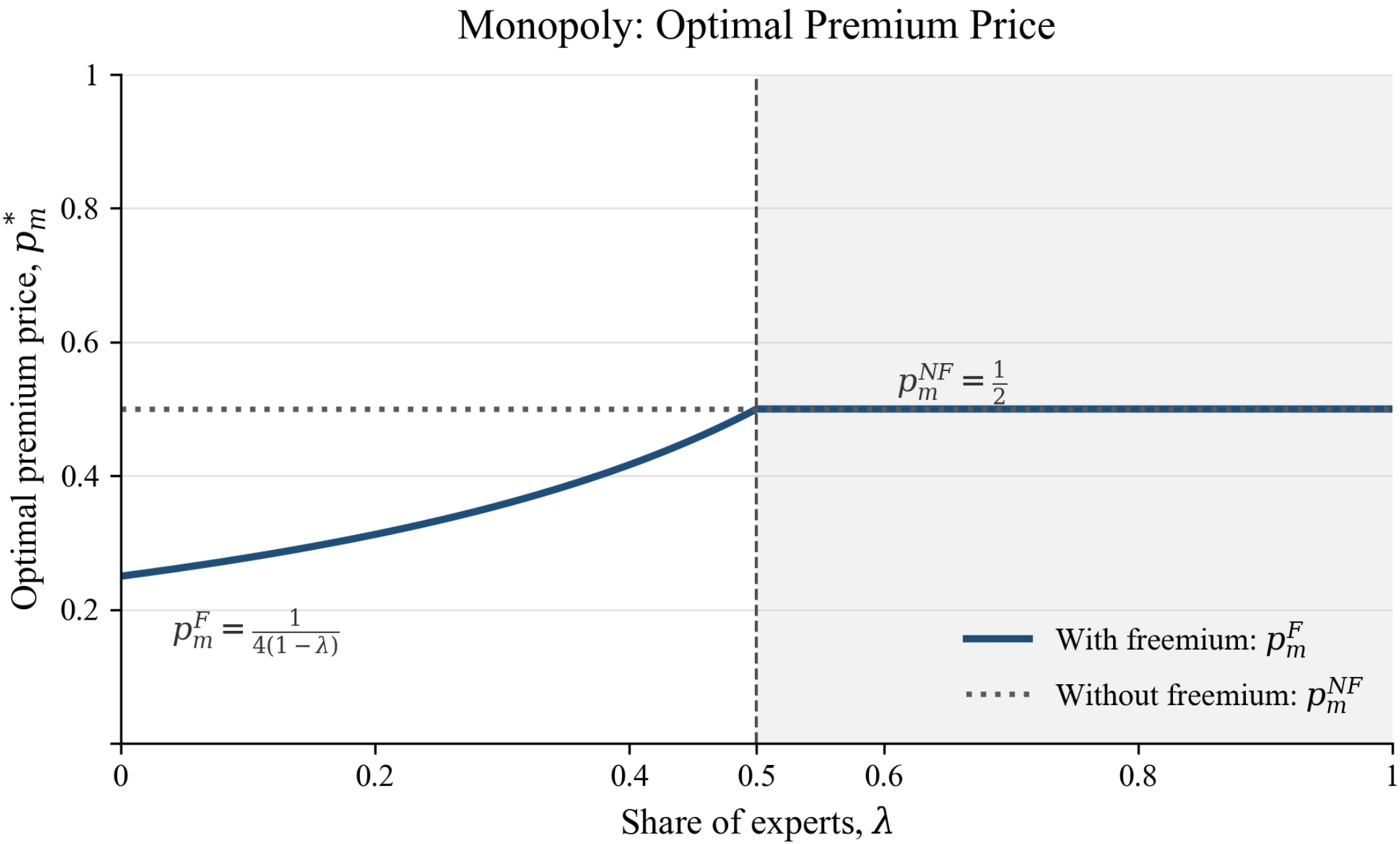
cannibalization cost

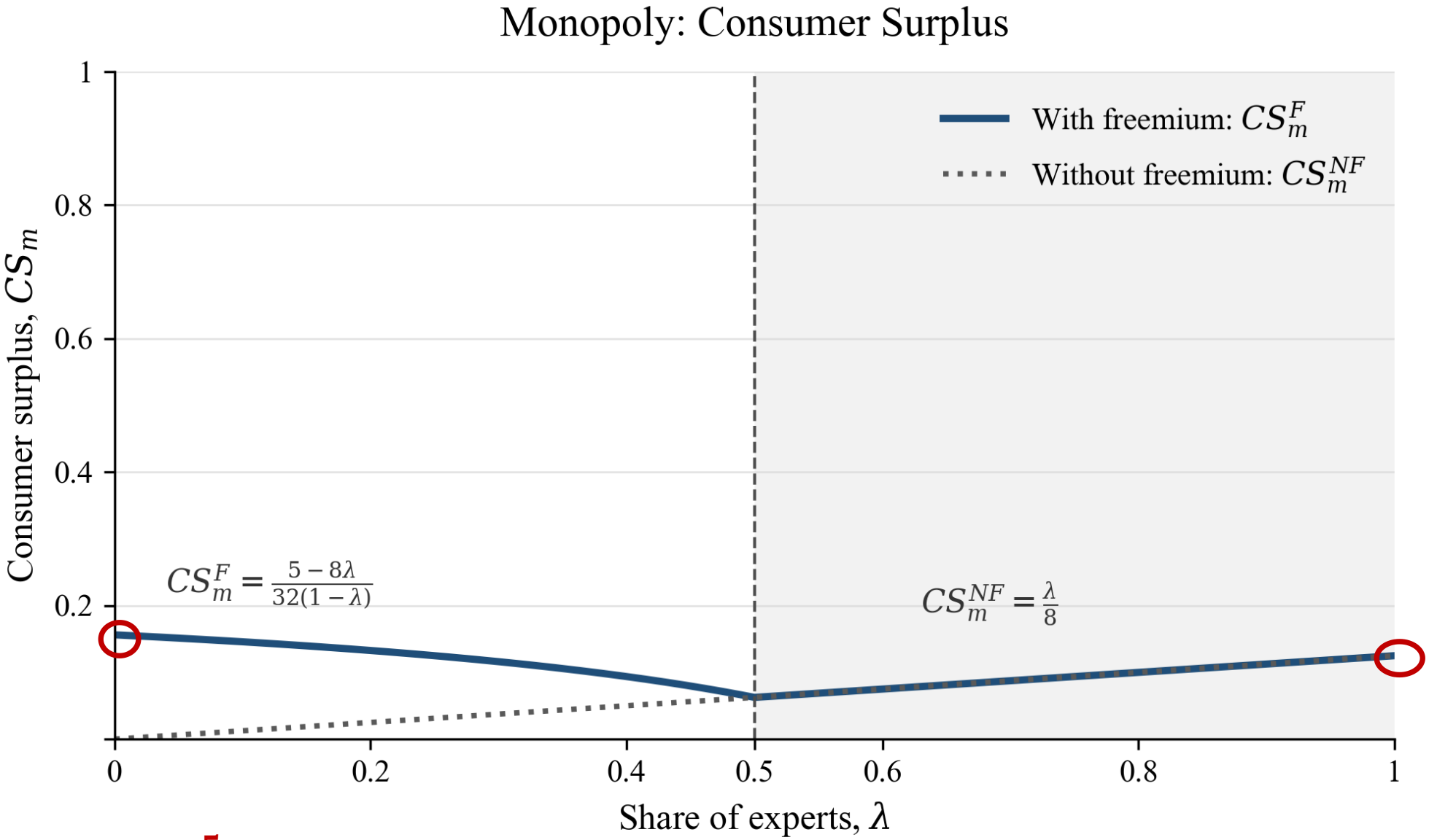
3.1 Monopoly

- No Freemium
  - Optimal decision-making leads to:
  - $p_{NF}^{m*} = \frac{1}{2}$
  - $D_{NF}^{m*} = \frac{\lambda}{2}$
  - $\prod^{*|NF} = \frac{\lambda}{4}$

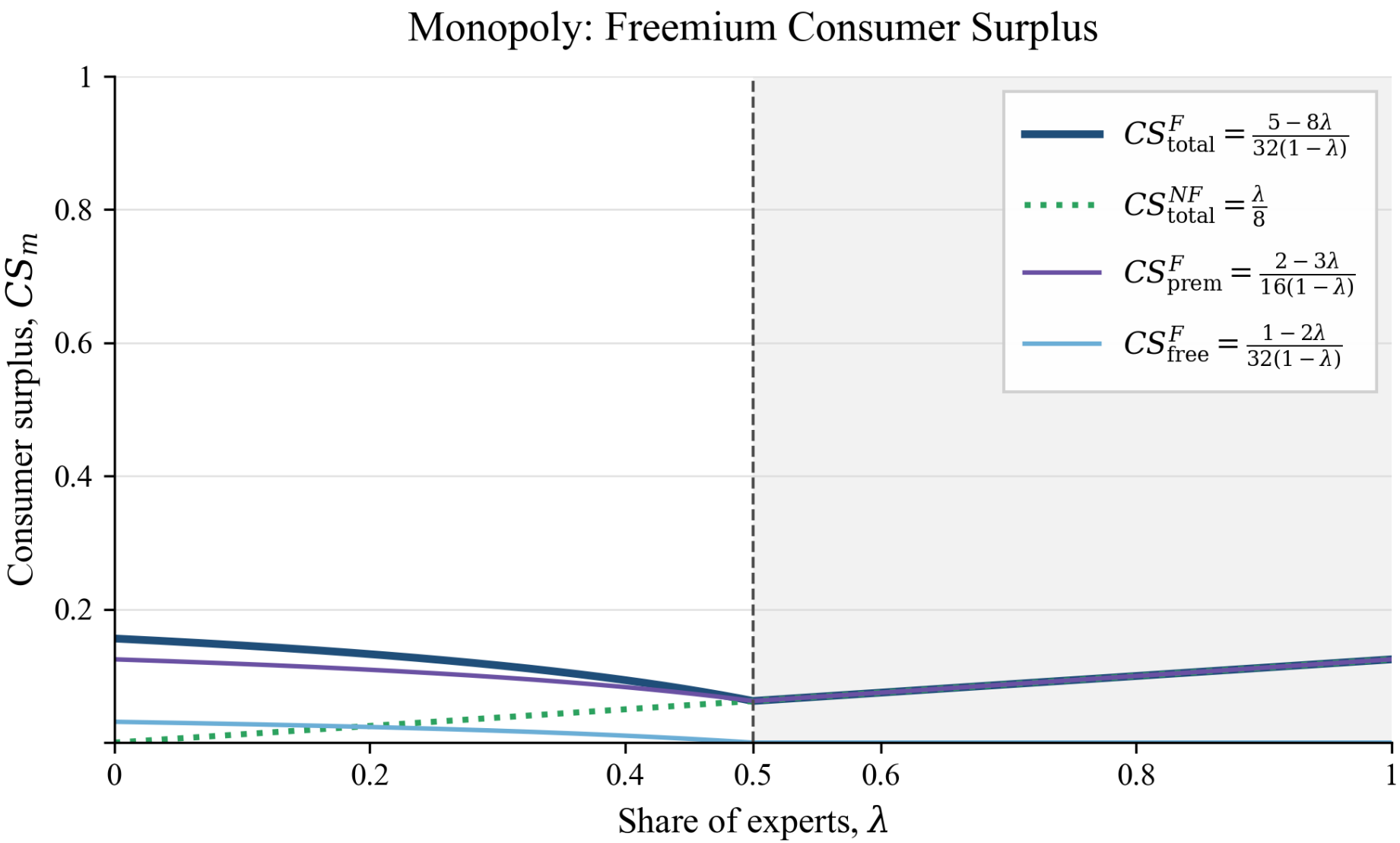
- **Freemium**
  - Optimal quality level pinned down by:
  - $$ag'(a) + g(a) = \frac{-\lambda}{1-\lambda}$$
  - $$a^{m*} = \begin{cases} \frac{1}{2(1-\lambda)}, & if\ \lambda \leq \frac{1}{2} \\ 1, & otherwise \end{cases}$$
  - $p_F^m = \frac{a_m^*}{2}$
  - $$\Pi_F^{m*} = \begin{cases} \frac{1}{2} \cdot \frac{1}{8(1-\lambda)}, & if\ \lambda \leq \frac{1}{2} \\ \frac{\lambda}{4}, & otherwise \end{cases}$$


Monopoly: Optimal Freemium Quality
$1-\alpha_m^* = \max\left\{1-\frac{1}{2(1-\lambda)}, 0\right\}$
Optimal freemium quality, $1-\alpha_m^*$
1
0.8
0.6
0.4
0.2
0
0.2
0.4
0.5
0.6
0.8
1
Share of experts, λ


Monopoly: Optimal Premium Price
Optimal premium price, p_m^*
1
0.8
0.6
0.4
0.2
0
0.2
0.4
0.5
0.6
0.8
1
Share of experts, λ
$p_m^{NF} = \frac{1}{2}$
$p_m^F = \frac{1}{4(1-\lambda)}$
With freemium: p_m^F
Without freemium: p_m^{NF}



$$CS^m_{total}(\lambda = 0) = \frac{5}{4 \cdot 8} > CS^m_{total}(\lambda = 1) = \frac{4}{4 \cdot 8}$$


Monopoly: Freemium Consumer Surplus
Consumer surplus, CS_m
1
0.8
0.6
0.4
0.2
0
0.2
0.4
0.5
0.6
0.8
1
Share of experts, λ
$CS^F_{\text{total}} = \frac{5-8\lambda}{32(1-\lambda)}$
$CS^{NF}_{\text{total}} = \frac{\lambda}{8}$
$CS^F_{\text{prem}} = \frac{2-3\lambda}{16(1-\lambda)}$
$CS^F_{\text{free}} = \frac{1-2\lambda}{32(1-\lambda)}$

3.2 Duopoly

- Firm 1's paid app quality: 1
- Firm 2's paid app quality: $1 - \omega$
- $\omega \in [0,1]$: degree of differentiation
- Competition in prices
- Timing:
  - *Stage 1: HQ firm chooses* $1 - a$
  - *Stage 2: Both firms choose prices simultaneously & independently*

3.2 Duopoly

No Freemium

- Only experts, λ, in the market
- Demands

$$D_1^D(p_1, p_2) = \left(1 - \frac{p_1 - p_2}{\omega}\right)\lambda$$

$$D_2^D(p_1, p_2) = \left(\frac{p_1 - p_2}{\omega} - \frac{p_2}{1-\omega}\right)\lambda$$

Freemium

- Firm 1 can now attract naïve users
- **Learning externalities (no switching costs):** informed users learn about all offerings
  - *can therefore price compare*
- Profits

$$\Pi_1^D = p_1 D_1 = p_1\left(1 - \frac{(p_1 - p_2)}{\omega}\right)\left(\lambda + (1-\alpha)(1-\lambda)\right)$$

$$\Pi_2^D = p_2 D_2 = p_2\left(\frac{(p_1 - p_2)}{\omega} - \frac{p_2}{\alpha - \omega}\right)\left(\lambda + (1-\alpha)(1-\lambda)\right)$$

cannibalization cost

attraction benefit

Duopoly with Learning Externalities

No Freemium

- $p_F^1 = \frac{2\omega}{3+\omega}$ and $p_F^2 = \frac{(1-\omega)\omega}{3+\omega}$

Freemium

- $p_F^1 = \frac{2a_d^*\omega}{3a_d^*+\omega}$ and $p_F^2 = \frac{(a_d^*-\omega)\omega}{3a_d^*+\omega}$

Duopoly

- **High Differentiation:** $\omega > a_m^* = \frac{1}{2(1-\lambda)}$, *where* $\lambda < \frac{1}{2}$

  Pure Monopoly

  No strategic interaction, firm 2 driven out

- **Medium Differentiation:** $\frac{1}{3(1-\lambda)} \leq \omega \leq \frac{1}{2(1-\lambda)}$ $where\ \lambda < \frac{2}{3}$

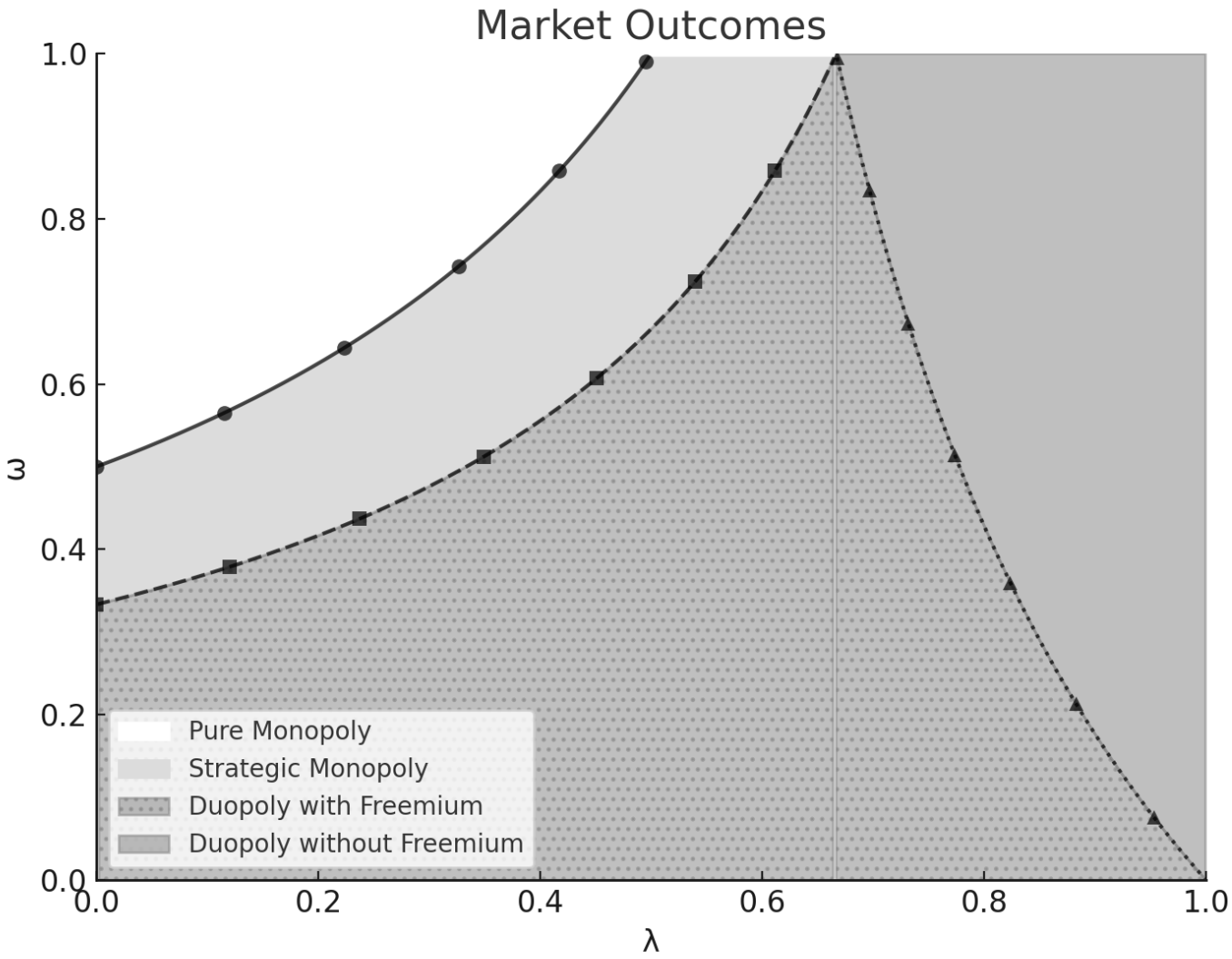
  Strategic Monopoly

  Freemium is strategically used to drive firm 2 out
  (launch of an free app with quality $1 - \omega$*)*

- **Low differentiation:** $\omega < \frac{1}{3(1-\lambda)}$

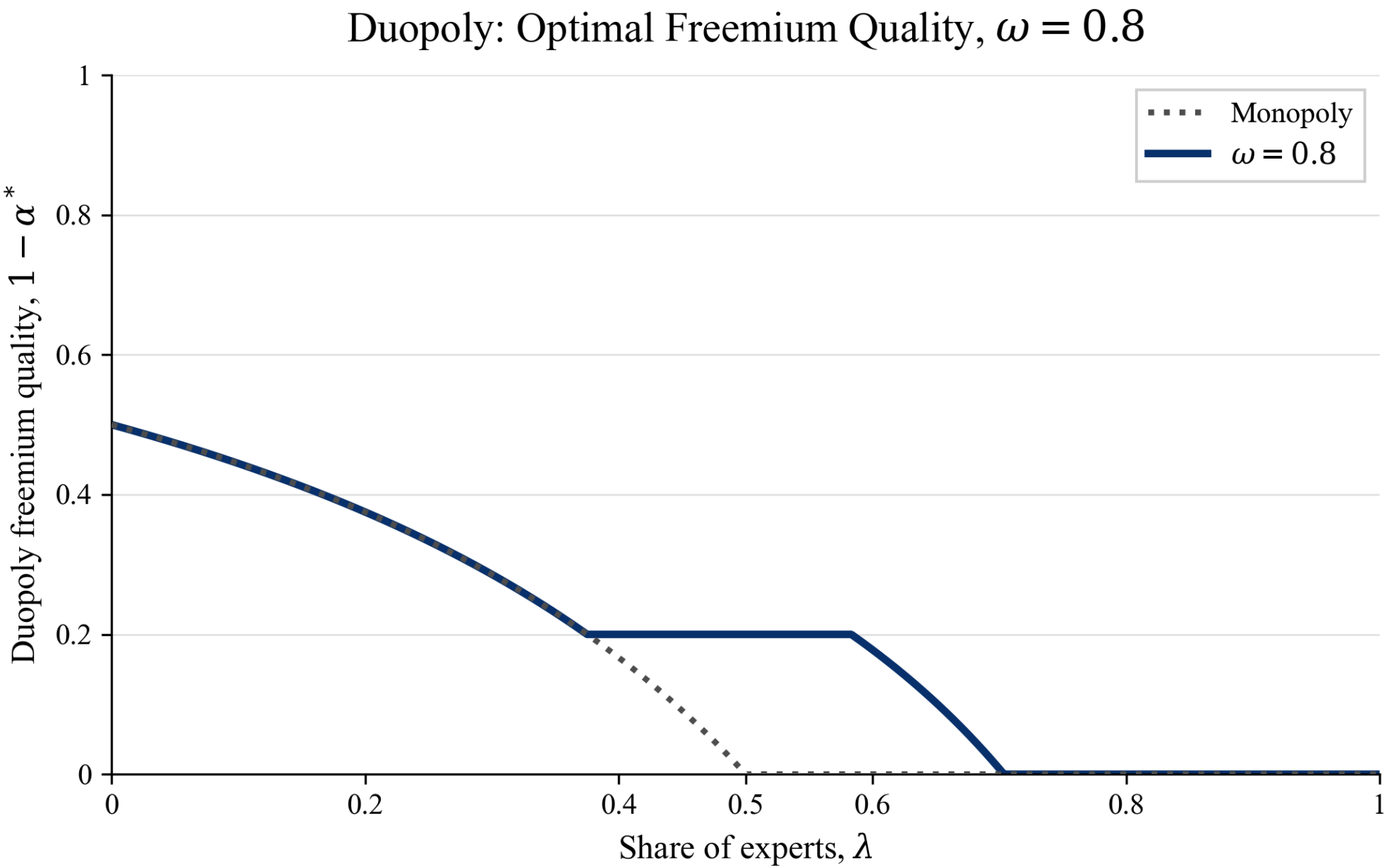
  Duopoly *(with or without freemium)*

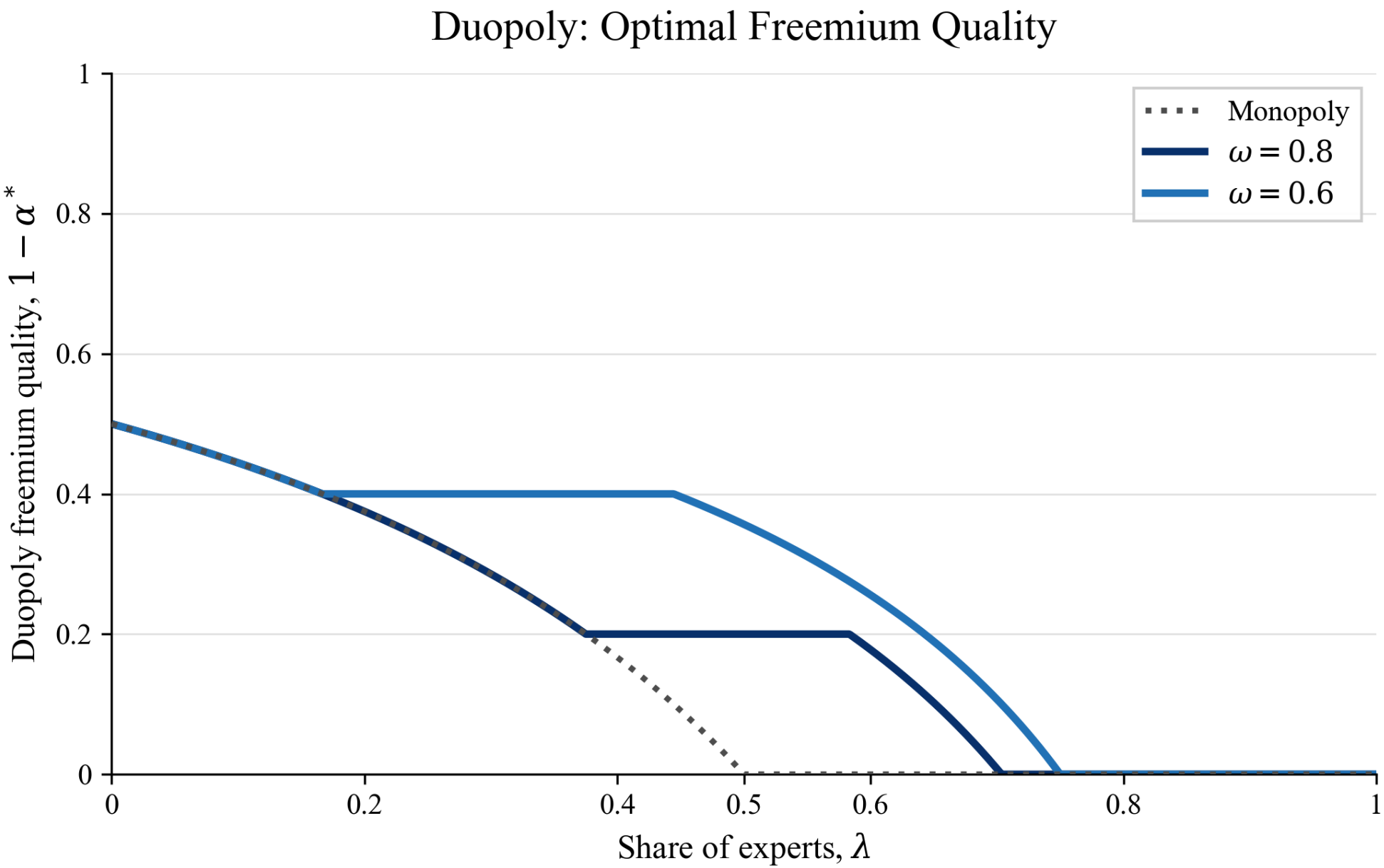
  Too expensive to completely drive the competitor out

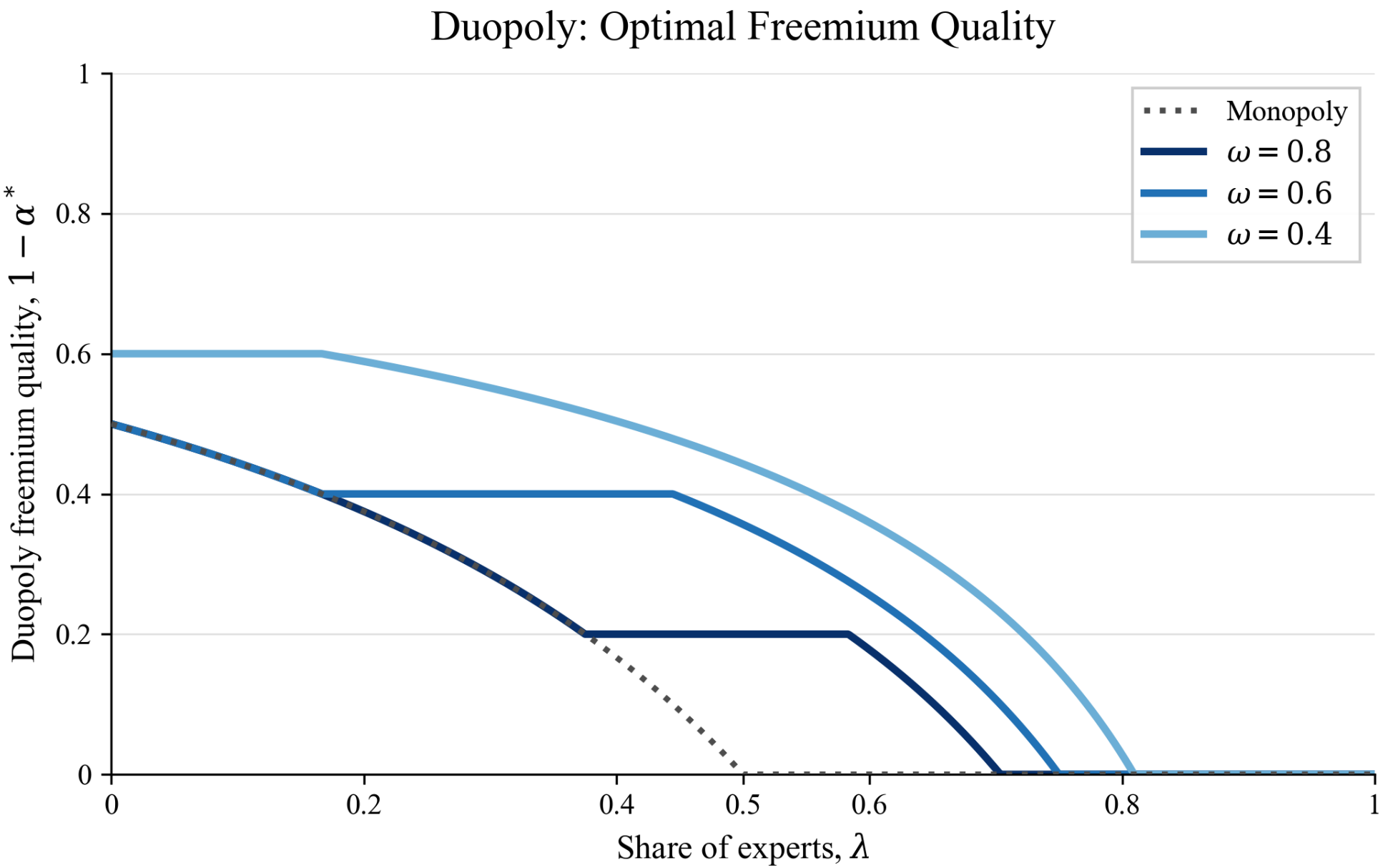

Market Outcomes
1.0
0.8
0.6
0.4
0.2
0.0
ϑ
0.0
0.2
0.4
0.6
0.8
1.0
λ
Pure Monopoly
Strategic Monopoly
Duopoly with Freemium
Duopoly without Freemium

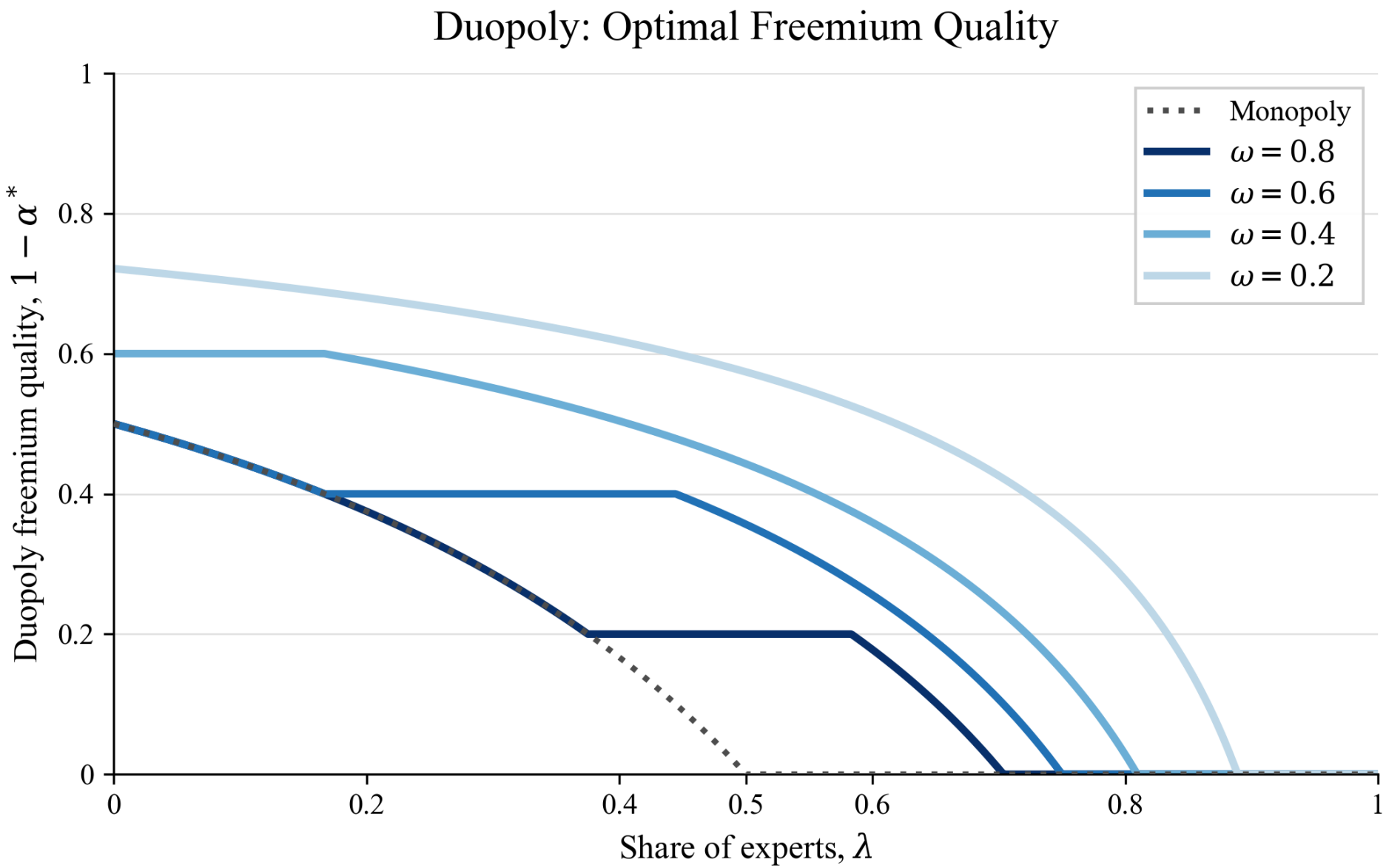
Duopoly with Learning Externalities: Optimal Freemium Quality

$$1-a^{*}=\begin{cases}1-\alpha_{m}^{*}=\max\left\{1-\dfrac{1}{2(1-\lambda)},0\right\}, & if\ \omega\geq\dfrac{1}{2(1-\lambda)}\ ,\\ 1-\omega\ , & if\ \dfrac{1}{2(1-\lambda)}>\omega>\dfrac{1}{3(1-\lambda)}\\ 1-a_{d}^{*}=\max\left\{1+\dfrac{\omega}{2}-\dfrac{\sqrt{3\omega(1-\lambda)(3\omega(1-\lambda)+8)}}{6(1-\lambda)},0\right\}, & otherwise\end{cases}$$


Duopoly: Optimal Freemium Quality, $\omega = 0.8$
Monopoly
$\omega = 0.8$
Duopoly freemium quality, $1 - \alpha^*$
Share of experts, λ
0
0.2
0.4
0.5
0.6
0.8
1


Duopoly: Optimal Freemium Quality
Monopoly
$\omega = 0.8$
$\omega = 0.6$
Duopoly freemium quality, $1 - \alpha^*$
Share of experts, λ
0
0.2
0.4
0.6
0.8
1
0
0.2
0.4
0.5
0.6
0.8
1


Duopoly: Optimal Freemium Quality
Monopoly
$\omega = 0.8$
$\omega = 0.6$
$\omega = 0.4$
Duopoly freemium quality, $1 - \alpha^*$
Share of experts, λ
0
0.2
0.4
0.5
0.6
0.8
1


Duopoly: Optimal Freemium Quality
Monopoly
$\omega = 0.8$
$\omega = 0.6$
$\omega = 0.4$
$\omega = 0.2$
Duopoly freemium quality, $1 - \alpha^*$
Share of experts, λ
0
0.2
0.4
0.5
0.6
0.8
1

Duopoly with LE: Prices

$$p_1^* = \begin{cases} \frac{a_m^*}{2} = \frac{1}{4(1-\lambda)} \\ \frac{a_{md}^*}{2} = \frac{\omega}{2}, \\ \frac{2a_d^*\omega}{3a_d^* + \omega}, \end{cases}$$

$$if\ \omega \geq \frac{1}{2(1-\lambda)}\ ,$$

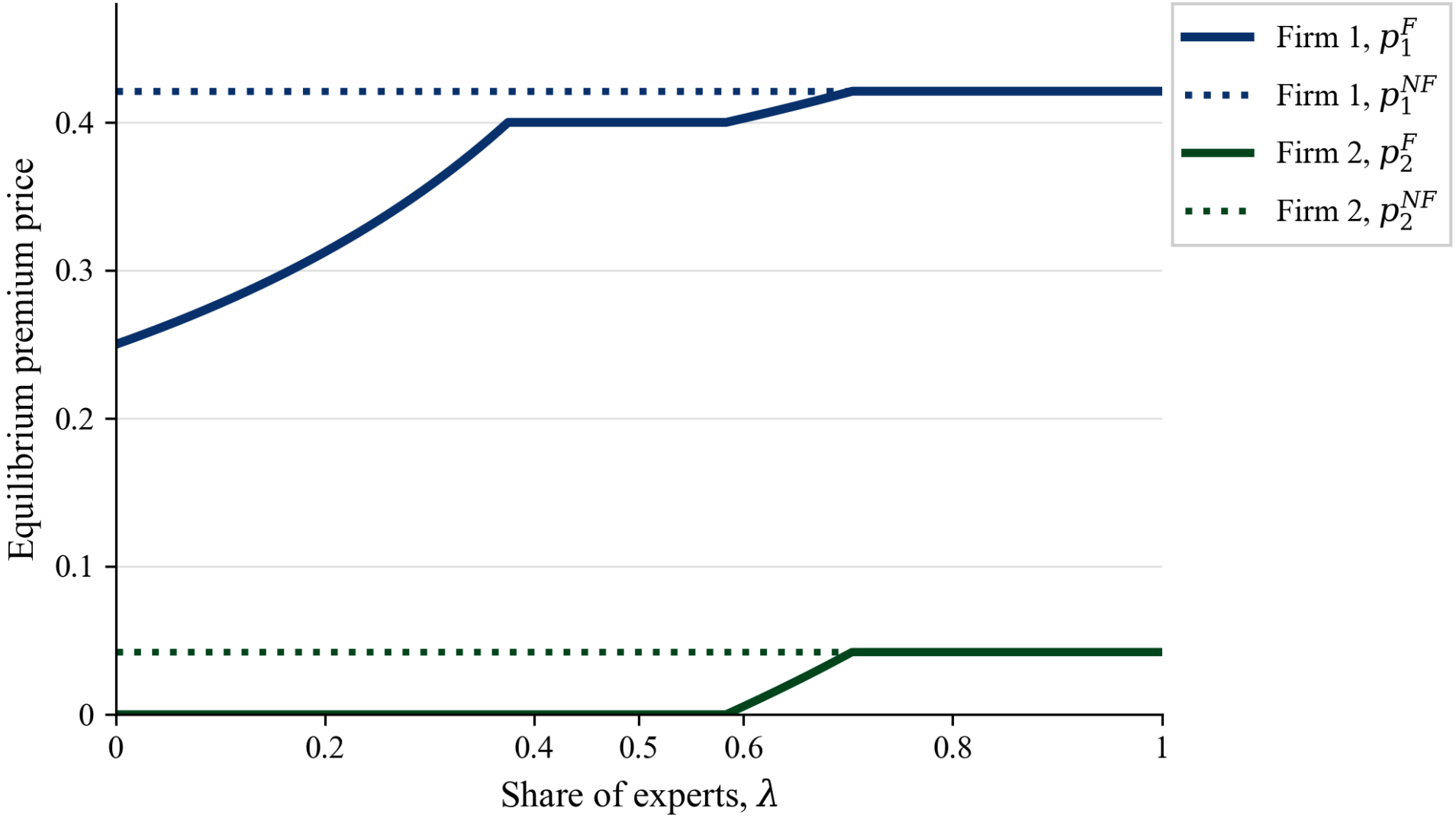
$$if\ \frac{1}{2(1-\lambda)} > \omega > \frac{1}{3(1-\lambda)}$$

$$otherwise$$

$p_2^* = \frac{(a_d^* - \omega)\omega}{3a_d^* + \omega}$, if $\omega \leq \frac{1}{3(1-\lambda)}$

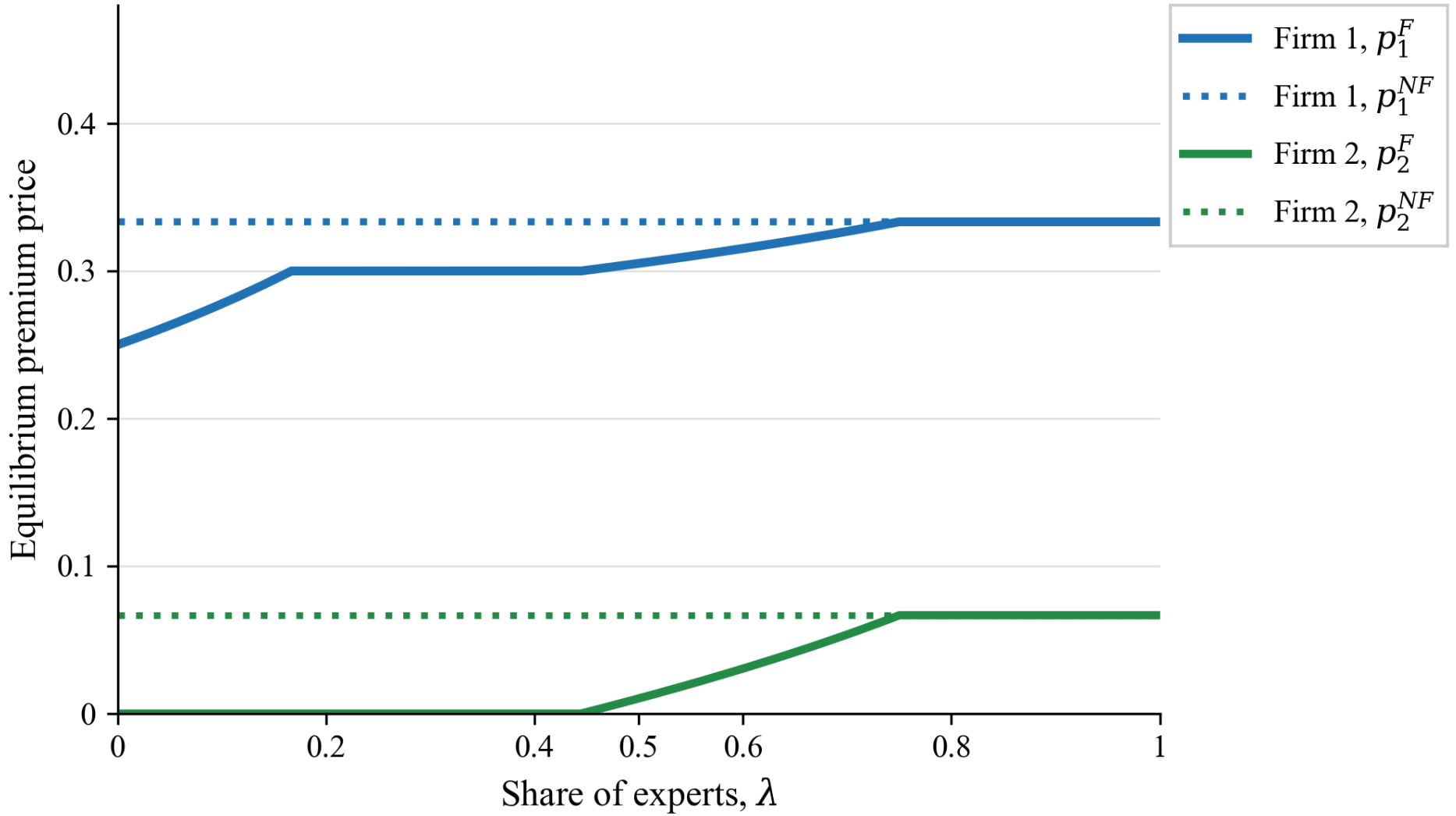
Duopoly: Equilibrium Prices

$\omega = 0.8$



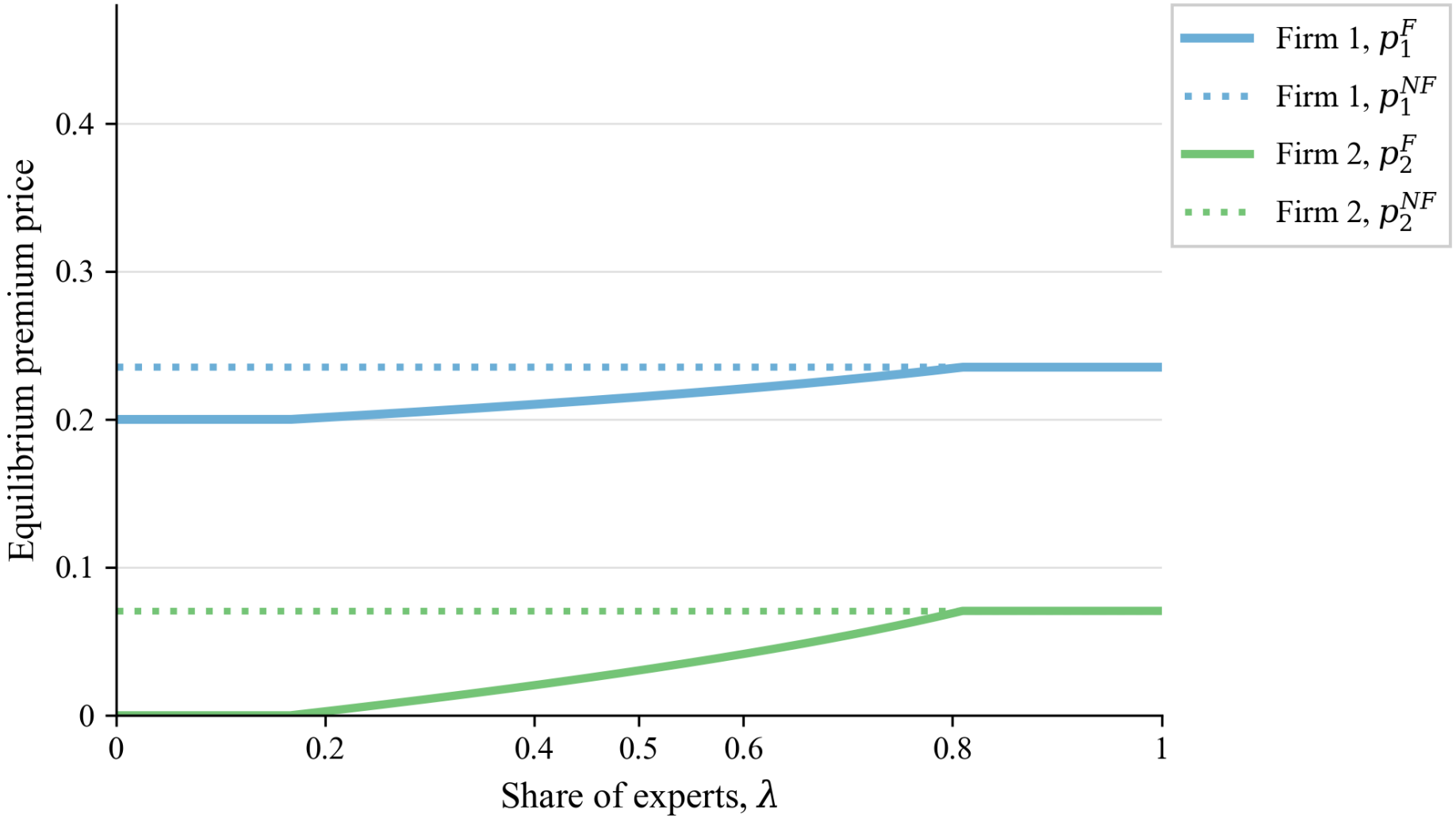
Duopoly: Equilibrium Prices

$\omega = 0.6$



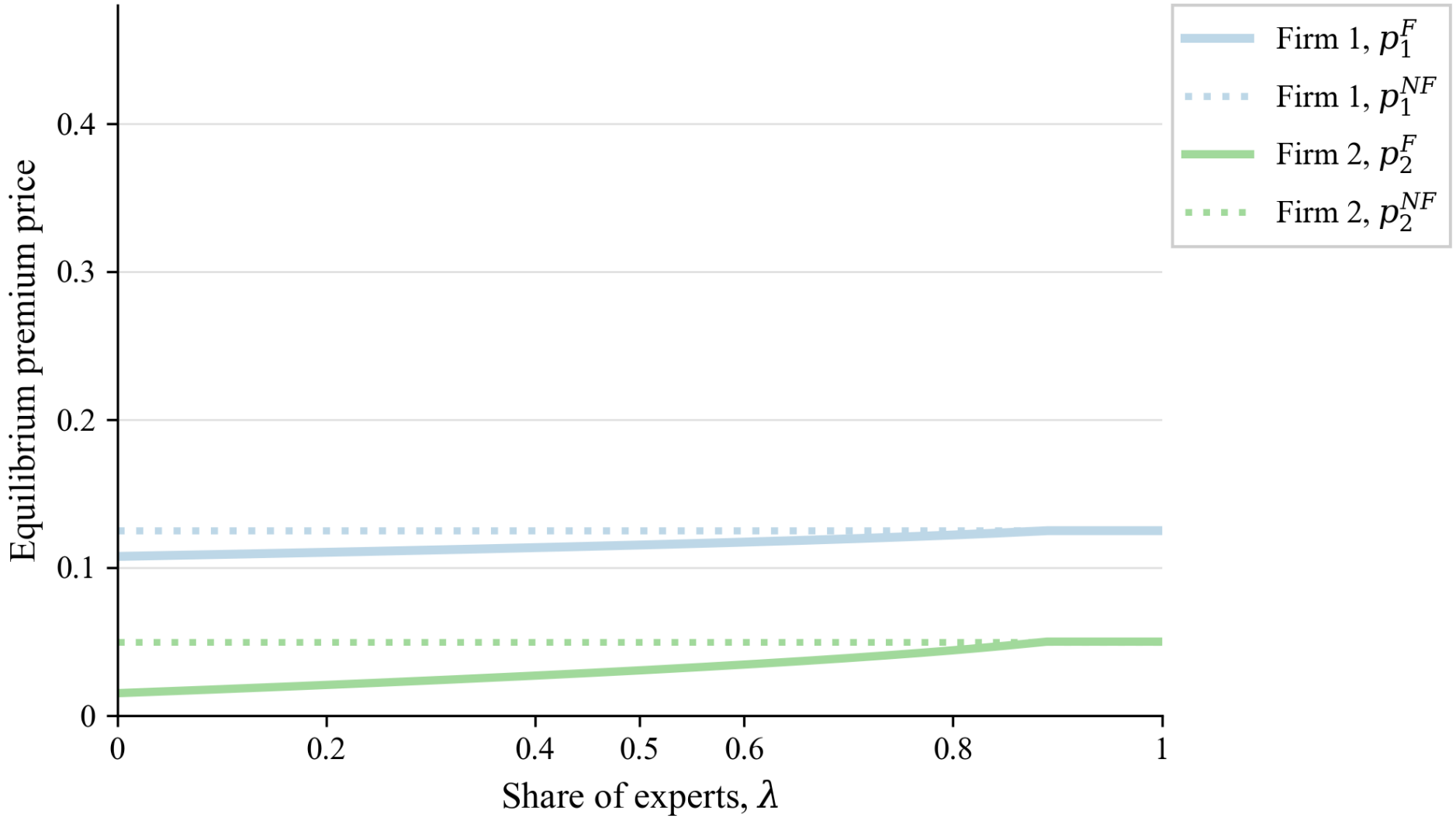
Duopoly: Equilibrium Prices

$\omega = 0.4$



Duopoly: Equilibrium Prices

$\omega = 0.2$

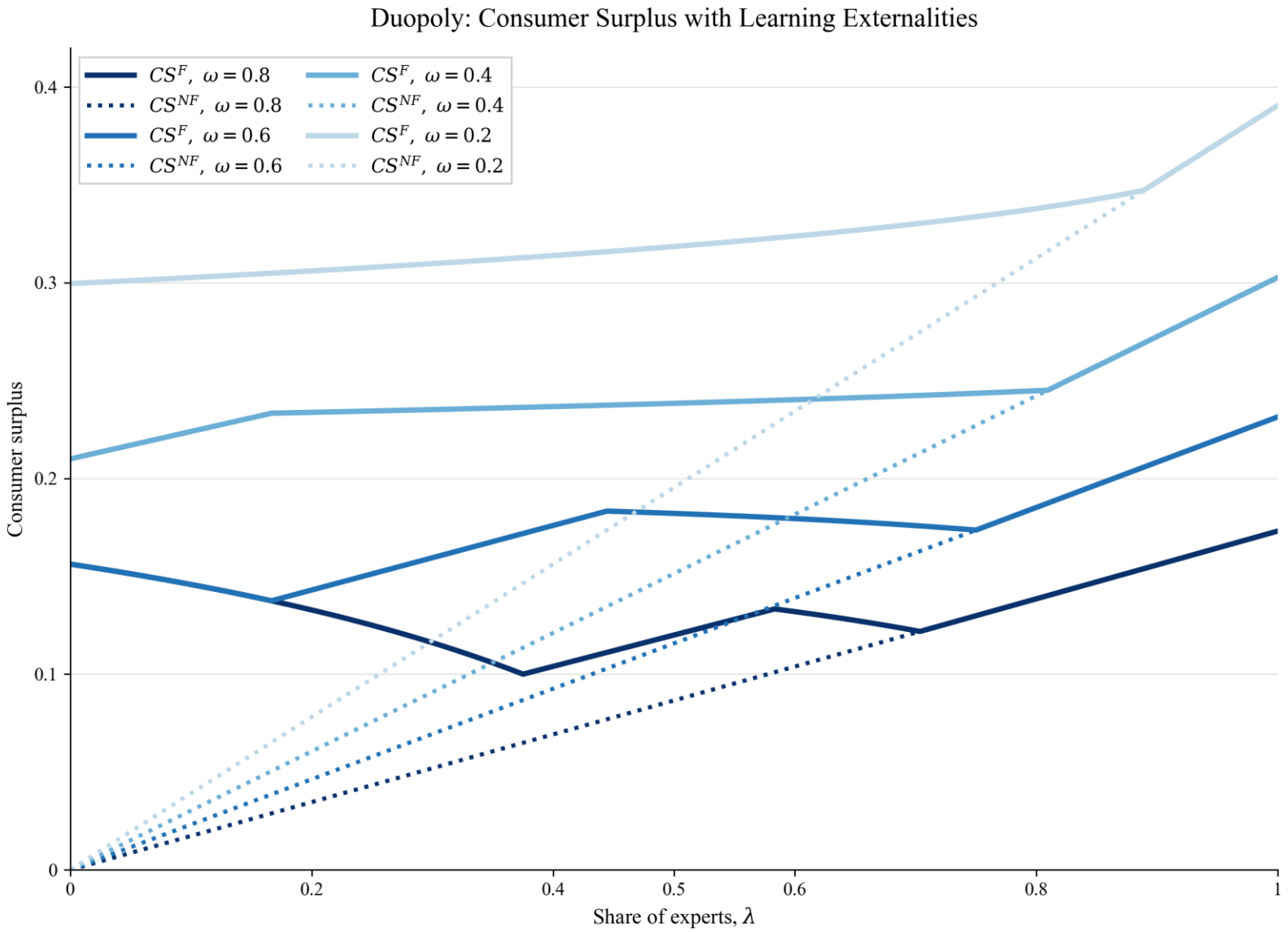


Duopoly with LE: Consumer Surplus

- $$CS_F^d = \begin{cases} \frac{1}{16}\left(4 - \frac{3}{2(1-\lambda)}\right), & if\ \omega \geq \frac{1}{2(1-\lambda)} \\ \frac{1}{8}\left(\lambda + (1-\lambda)(1-\omega)\right) \cdot (4 - 3\omega), & if\ \frac{1}{2(1-\lambda)} > \omega \geq \frac{1}{3(1-\lambda)} \\ \frac{1}{2}\frac{\left(\lambda + (1-\lambda)\left(1-a_d^*\right)\right)}{\left(3a_d^* + \omega\right)^2} \cdot [a_d^*(9a_d^* - 11a_d^*\omega + 6\omega) + (1-a_d^*)\omega^2], & otherwise \end{cases}$$

- $$where \quad \alpha_{\mathrm{d}}^* \equiv \min\left\{-\frac{\omega}{2} + \frac{\sqrt{3\omega(1-\lambda)(3\omega(1-\lambda)+8)}}{6(1-\lambda)}, 1\right\}$$

Duopoly with LE: Consumer Surplus



Duopoly without Learning Externalities

- **No Freemium**

Only experts, λ, in the market

Demands

$$D_1^D(p_1, p_2) = \left(1 - \frac{p_1 - p_2}{\omega}\right)\lambda$$

$$D_2^D(p_1, p_2) = \left(\frac{p_1 - p_2}{\omega} - \frac{p_2}{1 - \omega}\right)\lambda$$

- **Freemium**

Firm 1 can approach naïve users

Informed naïve users are locked-in

Demands:

$$D_1^N = \lambda\left(1 - \frac{p_1 - p_2}{\omega}\right) + (1 - \lambda)(1 - \alpha)\left(1 - \frac{p_1}{\alpha}\right)$$

$$D_2^N = \lambda\left(\frac{p_1 - p_2}{\omega} - \frac{p_2}{\alpha - \omega}\right)$$

Cannibalization cost

Attraction benefit (monopoly)

Duopoly without Learning Externalities

- *No Freemium*

$$p_{NF}^{1} = \frac{2\omega}{3+\omega}$$

$$p_{NF}^{2} = \frac{(1-\omega)\omega}{3+\omega}$$

- Freemium

$$p_{F}^{1,ne} = \frac{2\alpha\omega[\lambda + (1-\lambda)(1-\alpha)]}{4[\alpha\lambda + \omega(1-\lambda)(1-\alpha)] - \lambda(\alpha-\omega)}$$

$$p_{F}^{2,ne} = \frac{\omega(\alpha-\omega)[\lambda + (1-\lambda)(1-\alpha)]}{4[\alpha\lambda + \omega(1-\lambda)(1-\alpha)] - \lambda(\alpha-\omega)}$$

Ambiguous effect on prices!

Duopoly with Learning Externalities

- For fixed freemium quality, price of firm 1 increases if:

$$\lambda < \frac{\alpha\omega + 3\alpha - 4\omega}{\alpha\omega + 3\alpha - 3\omega}$$

- For fixed freemium quality, price of firm 2 increases if:

$$\lambda < \frac{\alpha\omega + 3\alpha + 3\omega^2 - 7\omega}{\alpha\omega + 3\alpha + 3\omega^2 - 3\omega}$$

Subset of the range!

Note that in comparison to Freemium with Learning Externalities, prices are higher here

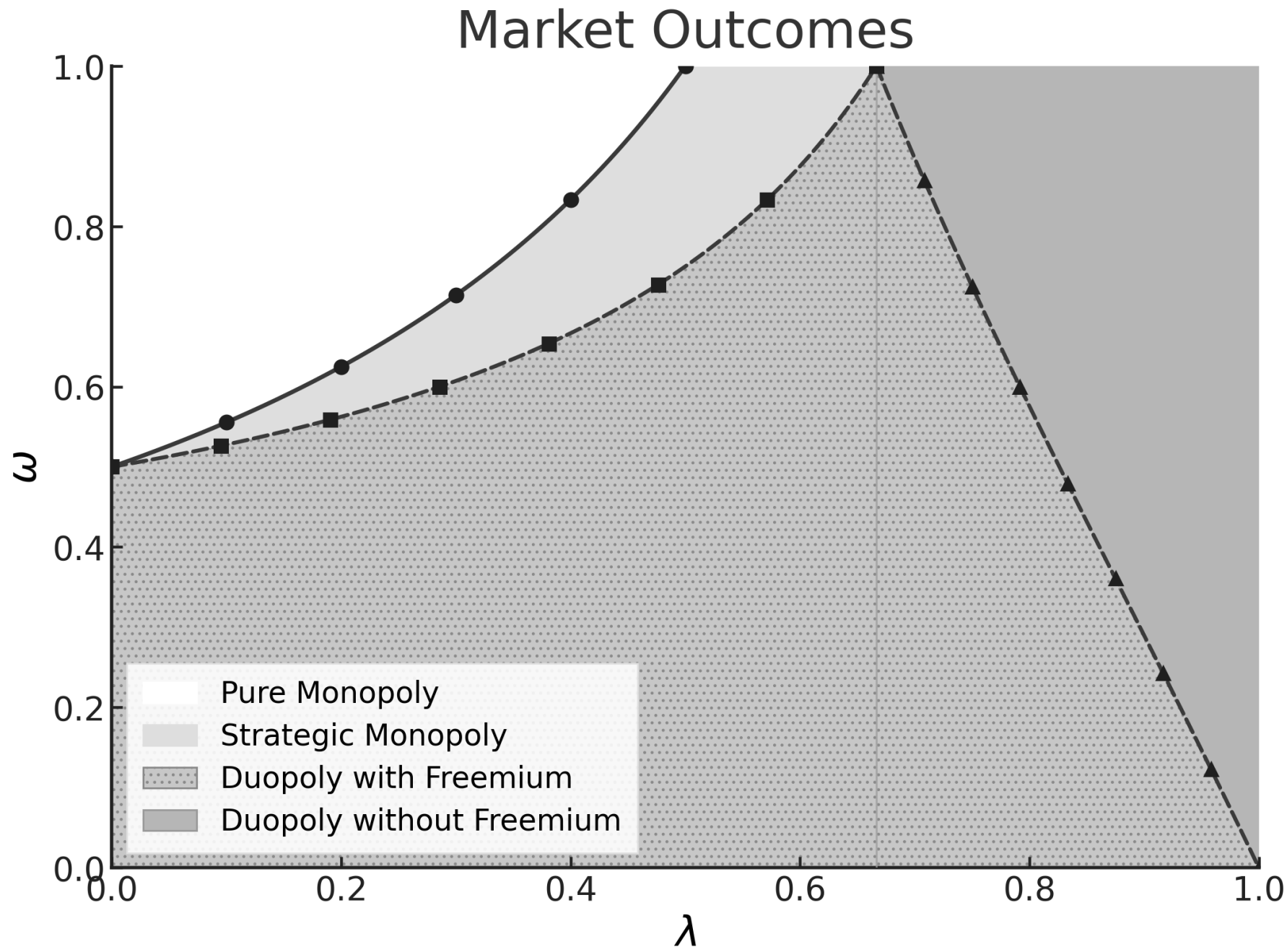
Duopoly without Learning Externalities

$$\alpha_N^*(\lambda,\omega)=\begin{cases} min\left\{\frac{1}{2(1-\lambda)},1\right\} & ,\omega \geq min\left\{\frac{1}{2(1-\lambda)},1\right\} \\ \omega & ,\omega < min\left\{\frac{1}{2(1-\lambda)},1\right\} and\ \omega \geq \frac{2-\lambda}{4(1-\lambda)} \\ \hat{\alpha}_N(\lambda,\omega) & ,\omega < \frac{2-\lambda}{4(1-\lambda)}\ and\ \lambda < \frac{\omega^2-3\omega+6}{\omega^2-\omega+6} \\ 1 & ,otherwise \end{cases}$$

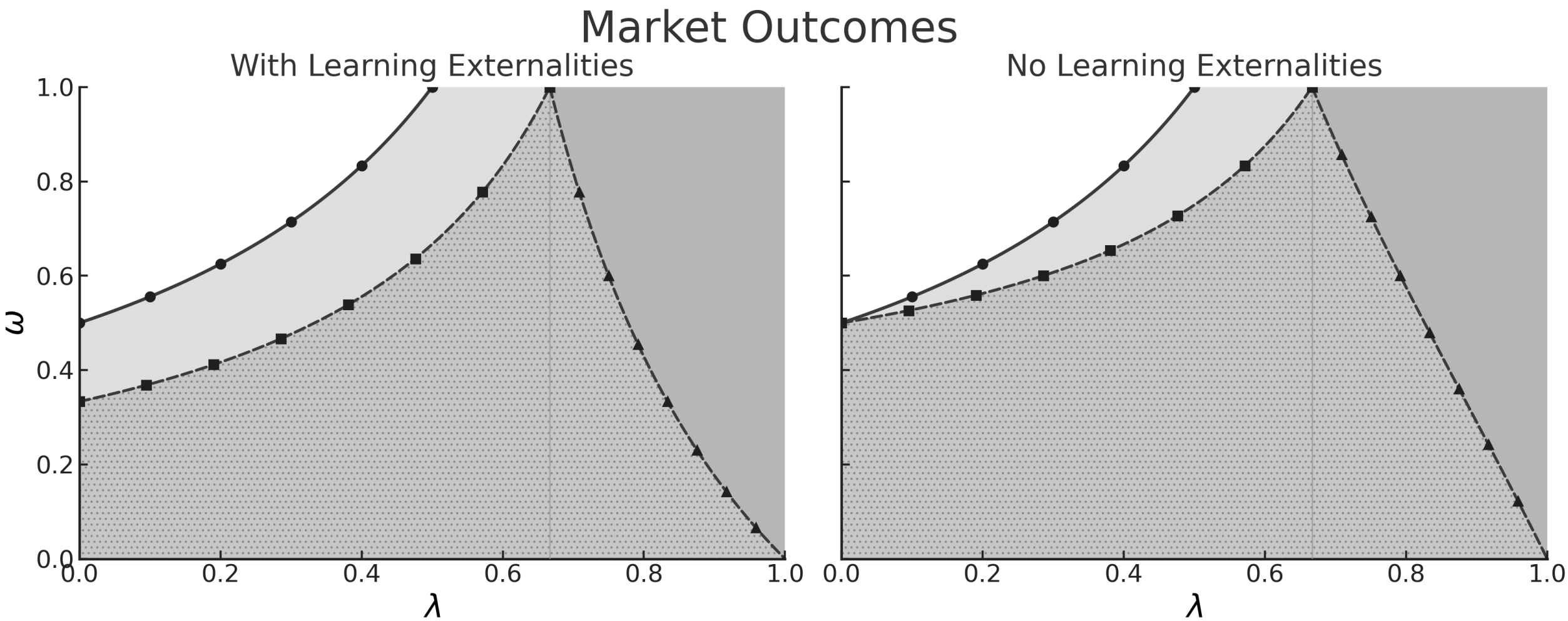
Where $\hat{\alpha}_N(\lambda,\omega)$ is the unique solution in $\omega < \alpha < 1$ to

$$\frac{1}{\alpha}-\frac{2(1-\lambda)}{\lambda+(1-\lambda)(1-\alpha)}+\frac{\lambda-\omega(1-\lambda)}{\alpha\lambda+\omega(1-\lambda)(1-\alpha)}-\frac{2[3\lambda-4\omega(1-\lambda)]}{4[\alpha\lambda+\omega(1-\lambda)(1-\alpha)]-\lambda(\alpha-\omega)}=0$$

No closed form solution!


Market Outcomes
1.0
0.8
0.6
0.4
0.2
0.0
ω
0.0
0.2
0.4
0.6
0.8
1.0
λ
Pure Monopoly
Strategic Monopoly
Duopoly with Freemium
Duopoly without Freemium

Market Outcomes



3.2 No Learning externalities

- Informed naïve users **locked in**
  - *unable to price compare*
- HQ firm reluctant to engage in competition for experts
  - *Mostly so when low ω, low λ*
  - *That ↑ firm 2's market power over them*
- Some consumers may now be harmed
  - ***ω=0 (No Bertrand Paradox)***

4. Discussion

- Monopoly

  ↓ share of experts

  Profitable monetization method over the free users' base

- Duopoly
  - *Learning externalities:*

    High / Medium / Low Differentiation

    ↓ *prices*
  - *No Learning externalities:*

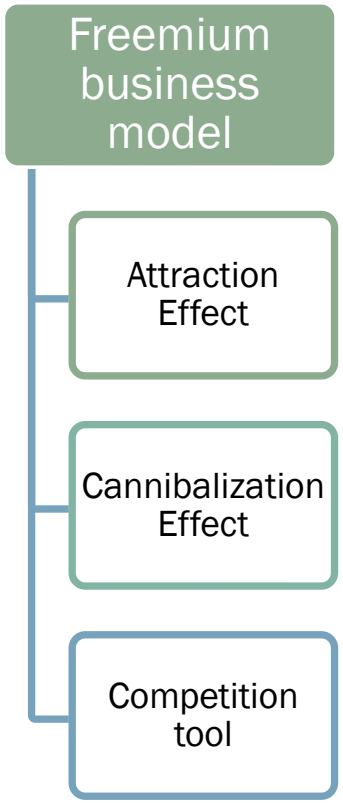
    Locked in consumers

    Mixed results

    ↑ *or* ↓ *of CS*

- Presence of learning externalities: depends on the nature of the app (games vs note taking apps, learning curve, switching costs, difficulty to learn quality & prices)
- Further research: dynamic setting, competition in Freemia, data concerns (freemium may incentivize further exploitation), lock in effects due to long-term usage, antitrust regulation, innovation

5. Conclusion



Monopoly

Did you play that free game on Android
Yes
How much did it cost you?
Everything

6. References

- [1] Hüttel, B. A., Schumann, J. H., Mende, M., Scott, M. L., & Wagner, C. J. (2018). How consumers assess free e-services: The role of benefit-inflation and cost-deflation effects. Journal of Service Research, 21(3), 267-283.
- [2] Bawa, K., & Shoemaker, R. (2004). The effects of free sample promotions on incremental brand sales. *Marketing Science*, *23*(3), 345-363.
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- [5] Hamari, J., Hanner, N., & Koivisto, J. (2020). "Why pay premium in freemium services?" A study on perceived value, continued use and purchase intentions in free-to-play games. International Journal of Information Management, 51, 102040.