

# Informative Advertising and Product Design in Differentiated Product Markets

Guillem Roig

ATE and The University of Melbourne

14th December, 2015

# Motivation

- Multi-product firms sell **components** that cannot be used separately.

# Motivation

- Multi-product firms sell **components** that cannot be used separately.
  - Firms produce the whole bundle creating a product system.
  - Consumers have heterogenous preferences over components.

# Motivation

- Multi-product firms sell **components** that cannot be used separately.
  - Firms produce the whole bundle creating a product system.
  - Consumers have heterogenous preferences over components.
- Decision over product design: **compatibility** with the rival.

# Motivation

- Multi-product firms sell **components** that cannot be used separately.
  - Firms produce the whole bundle creating a product system.
  - Consumers have heterogenous preferences over components.
- Decision over product design: **compatibility** with the rival.
- Firm spend resources to **inform** about the existence and characteristics of their product.

# Motivation

- Multi-product firms sell **components** that cannot be used separately.
  - Firms produce the whole bundle creating a product system.
  - Consumers have heterogenous preferences over components.
- Decision over product design: **compatibility** with the rival.
- Firm spend resources to **inform** about the existence and characteristics of their product.
- **Compatibility** and **advertising** decisions affect market competition.

# New Features...

- 1 Consumers' ability to create the desired bundle not only depends on product **compatibility** but also on consumers' **information**.

# New Features...

- 1 Consumers' ability to create the desired bundle not only depends on product **compatibility** but also on consumers' **information**.
- 2 Firms have two strategic decisions that affect competition in the market.
  - The level of **compatibility** between components produced by different firms.
  - Available **information** in the market.



# Questions I ask

- 1 Which are the implications of product design on firms' advertising decisions?

# Questions I ask

- ① Which are the implications of product design on firms' advertising decisions?
- ② What are the strategic considerations of product design and advertising?

# Questions I ask

- ① Which are the implications of product design on firms' advertising decisions?
- ② What are the strategic considerations of product design and advertising?
- ③ Are there inefficiencies?
  - Is there too much product compatibility?
  - Is advertisement excessive or undersupplied?

# Model

- Each of two firms  $i \in \{A, B\}$  produce two components  $\{x_i, y_i\}$  that form a product system.

# Model

- Each of two firms  $i \in \{A, B\}$  produce two components  $\{x_i, y_i\}$  that form a product system.
- Consumers have **heterogenous tastes** for each component and obtain gross utility  $V$  from consumption of a system.

# Model

- Each of two firms  $i \in \{A, B\}$  produce two components  $\{x_i, y_i\}$  that form a product system.
- Consumers have **heterogenous tastes** for each component and obtain gross utility  $V$  from consumption of a system.
- **Three stage** game.
  - 1 Firms choose compatibility with rival's component. Product incompatibility  $z \in (0, 1)$  (Consumers' utility loss).

# Model

- Each of two firms  $i \in \{A, B\}$  produce two components  $\{x_i, y_i\}$  that form a product system.
- Consumers have **heterogenous tastes** for each component and obtain gross utility  $V$  from consumption of a system.
- **Three stage** game.
  - 1 Firms choose compatibility with rival's component. Product incompatibility  $z \in (0, 1)$  (Consumers' utility loss).
  - 2 Firms decide on advertising intensity  $\phi_i \in (0, 1)$  and prices  $\{p_i^x, p_i^y\}$ .
    - Cost of advertising  $E(\phi_i, \alpha)$ .

# Model

- Each of two firms  $i \in \{A, B\}$  produce two components  $\{x_i, y_i\}$  that form a product system.
- Consumers have **heterogenous tastes** for each component and obtain gross utility  $V$  from consumption of a system.
- **Three stage** game.
  - ① Firms choose compatibility with rival's component. Product incompatibility  $z \in (0, 1)$  (Consumers' utility loss).
  - ② Firms decide on advertising intensity  $\phi_i \in (0, 1)$  and prices  $\{p_i^x, p_i^y\}$ .
    - Cost of advertising  $E(\phi_i, \alpha)$ .
  - ③ Consumers make their purchasing decisions.
    - Restriction to a **fully-covered market!**



# Model

Location: Hotelling square of length 1.

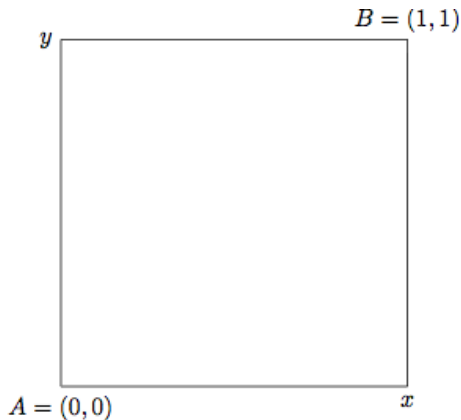


Figure: Location of firms and consumers.

# Model

Location: Hotelling square of length 1.

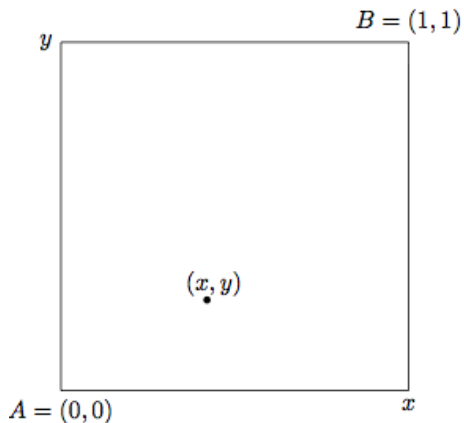


Figure: Location of firms and consumers.

# Model

Location: Hotelling square of length 1.

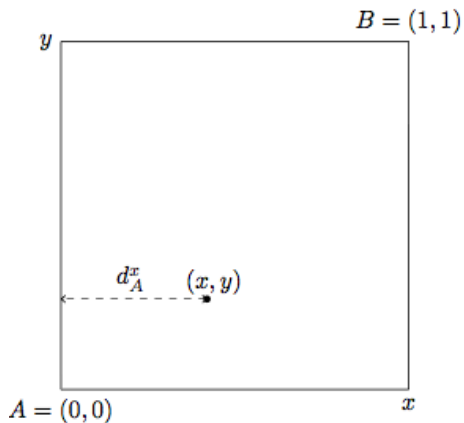


Figure: Location of firms and consumers.

# Model

Location: Hotelling square of length 1.

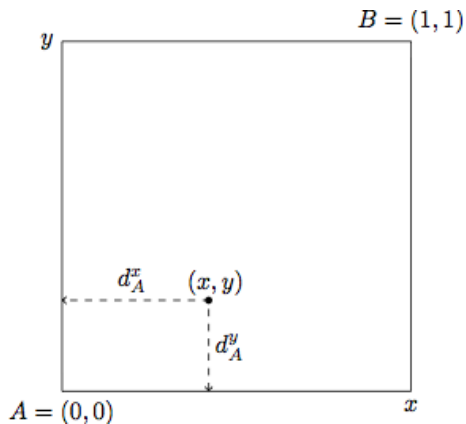


Figure: Location of firms and consumers.

# Model

Location: Hotelling square of length 1.

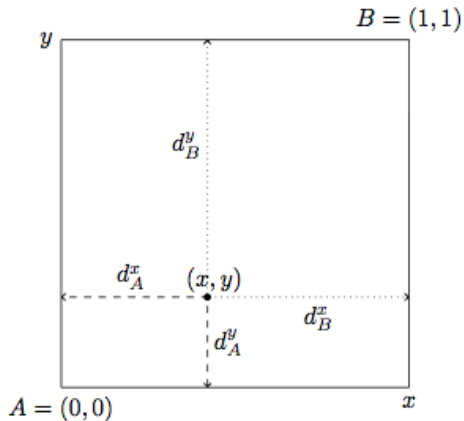


Figure: Location of firms and consumers.

# Purchasing decisions

$$V - (d_i^x + d_j^y) - p_i^x - p_j^y - z \times \mathbf{1}(i \neq j) \quad i, j = A, B,$$

# Purchasing decisions

$$V - \underbrace{(d_i^x + d_j^y)}_{\text{Preference cost}} - p_i^x - p_j^y - z \times \mathbf{1}(i \neq j) \quad i, j = A, B,$$

# Purchasing decisions

$$V - \underbrace{(d_i^x + d_j^y)}_{\text{Preference cost}} - p_i^x - p_j^y - \underbrace{z \times \mathbf{1}(i \neq j)}_{\text{Incompatibility cost}} \quad i, j = A, B,$$



# Selective consumers

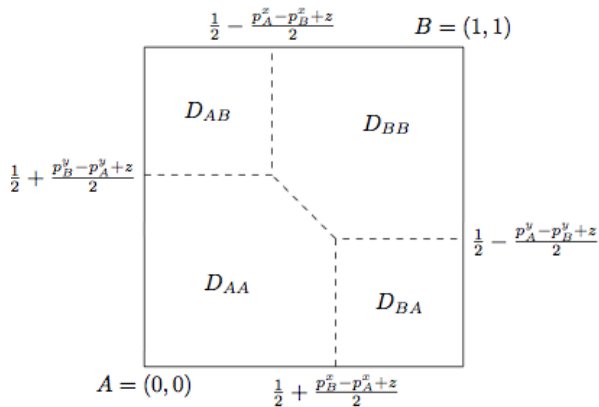


Figure: Demand regions for selective consumers with incompatibility  $z$ .

# Selective consumers

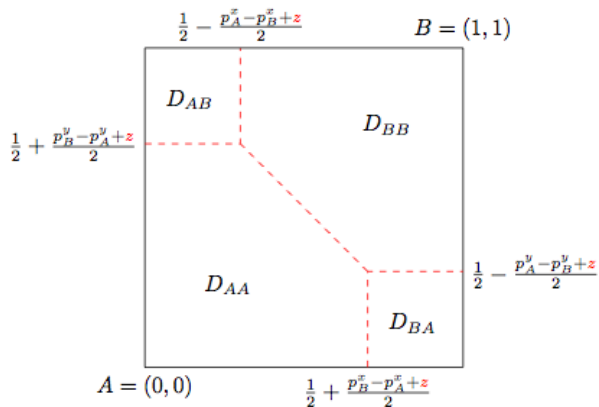


Figure: Demand regions for selective consumers with incompatibility  $z > \bar{z}$ .

# Captive consumers

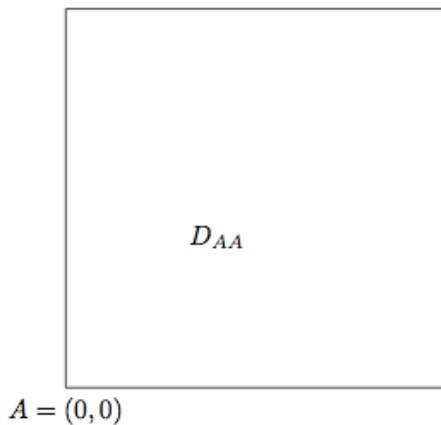


Figure: Demand for captive consumers.

# Advertising and prices

# Symmetric equilibrium

## Equilibrium condition

*If a symmetric pure strategy equilibrium exists, it is unique and characterized by:*

$$E_{\phi}(\hat{\phi}, \alpha) = \frac{(2 - \hat{\phi})^2}{\hat{\phi} \times (1 + z)}; \quad \hat{p} = \frac{2 - \hat{\phi}}{\hat{\phi} \times (1 + z)}.$$

# Symmetric equilibrium

## Equilibrium condition

*If a symmetric pure strategy equilibrium exists, it is unique and characterized by:*

$$E_{\phi}(\hat{\phi}, \alpha) = \frac{(2 - \hat{\phi})^2}{\hat{\phi} \times (1 + z)}; \quad \hat{p} = \frac{2 - \hat{\phi}}{\hat{\phi} \times (1 + z)}.$$

## Lemma

*i) Prices increase with compatibility but decrease with advertising effectiveness.*

$$d\hat{p}/d(-z) > 0, \quad d\hat{p}/d\alpha < 0.$$

# Equilibrium vs efficiency

## Equilibrium advertising

$$\underbrace{(1 - \hat{\phi}) 2\hat{p}}_{\text{Market size}} + \underbrace{2\hat{p}\frac{\hat{\phi}}{2}}_{\text{Stealing}} + D \times \frac{d\hat{p}}{d\hat{\phi}} = E_{\phi}(\hat{\phi}, \alpha).$$

# Equilibrium vs efficiency

## Equilibrium advertising

$$\underbrace{(1 - \hat{\phi}) 2\hat{p}}_{\text{Market size}} + \underbrace{2\hat{p}\frac{\hat{\phi}}{2}}_{\text{Stealing}} + D \times \frac{d\hat{p}}{d\hat{\phi}} = E_{\phi}(\hat{\phi}, \alpha).$$

## Efficient advertising

$$\underbrace{(1 - \phi^*) V}_{\text{Market size}} - \underbrace{\left( \frac{dIC(z, \phi^*)}{d(2\phi)} + \frac{dPC(z, \phi^*)}{d(2\phi)} \right)}_{\text{Matching}} = E_{\phi}(\phi^*, \alpha).$$



# Equilibrium vs efficiency

## Equilibrium advertising

$$\underbrace{(1 - \hat{\phi}) 2\hat{p}}_{\text{Market size}} + \underbrace{2\hat{p}\frac{\hat{\phi}}{2}}_{\text{Stealing}} + D \times \frac{d\hat{p}}{d\phi} = E_{\phi}(\hat{\phi}, \alpha).$$

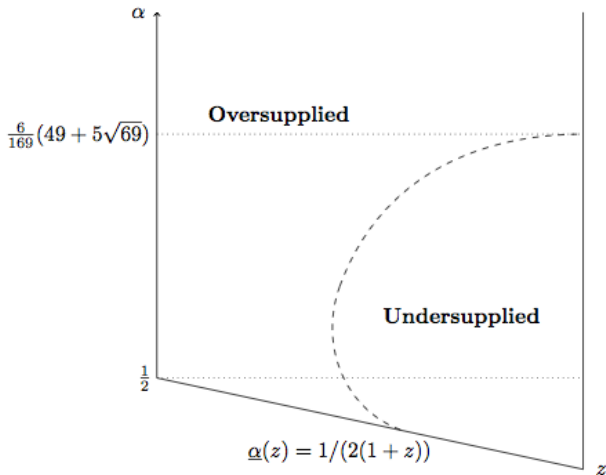
## Efficient advertising

$$\underbrace{(1 - \phi^*) V}_{\text{Market size}} - \underbrace{\left( \frac{dIC(z, \phi^*)}{d(2\phi)} + \frac{dPC(z, \phi^*)}{d(2\phi)} \right)}_{\text{Matching}} = E_{\phi}(\phi^*, \alpha).$$

## Proposition

*The equilibrium advertising intensity is not efficient. Advertisement is undersupplied when components' compatibility is low and oversupplied otherwise.*

$$E(\phi, \alpha) = \frac{\phi^2}{\alpha}; \quad \gamma(z) = \frac{1-z}{z}$$



# Compatibility decisions

## Equilibrium compatibility

$$\underbrace{\left(2(1 - \hat{\phi}(z, \alpha)) \frac{d\hat{\phi}(z, \alpha)}{d(-z_i)}\right)}_{\text{Market size}} \hat{p}(\max\{z_i, z_{-i}\}) - \underbrace{\left(E_{\phi}(\hat{\phi}, \alpha) \frac{d\hat{\phi}(z, \alpha)}{d(-z_i)}\right)}_{\text{Cost}}$$

$$+ \hat{\phi}(z, \alpha)(2 - \hat{\phi}(z, \alpha)) \underbrace{\left(\frac{d\hat{p}(\max\{z_i, z_{-i}\})}{d(-z_i)} + \frac{d\hat{p}(\max\{z_i, z_{-i}\})}{d\hat{\phi}(\cdot)} \frac{d\hat{\phi}(z, \alpha)}{d(-z_i)}\right)}_{\text{Competition}} = \gamma_{(-z)}(z_i)$$

## Equilibrium compatibility

$$\underbrace{\left(2(1 - \hat{\phi}(z, \alpha)) \frac{d\hat{\phi}(z, \alpha)}{d(-z_i)}\right)}_{\text{Market size}} \hat{p}(\max\{z_i, z_{-i}\}) - \underbrace{\left(E_{\phi}(\hat{\phi}, \alpha) \frac{d\hat{\phi}(z, \alpha)}{d(-z_i)}\right)}_{\text{Cost}}$$

$$+ \underbrace{\hat{\phi}(z, \alpha)(2 - \hat{\phi}(z, \alpha)) \left(\frac{d\hat{p}(\max\{z_i, z_{-i}\})}{d(-z_i)} + \frac{d\hat{p}(\max\{z_i, z_{-i}\})}{d\hat{\phi}(\cdot)} \frac{d\hat{\phi}(z, \alpha)}{d(-z_i)}\right)}_{\text{Competition}} = \gamma_{(-z)}(z_i)$$

## Efficient compatibility

$$- \underbrace{\left[\frac{dIC(z, \phi^*)}{d(-z)} + \frac{dPC(z, \phi^*)}{d(-z)}\right]}_{\text{Matching}} = \gamma_{(-z)}(z)$$

## Equilibrium compatibility

$$\underbrace{\left(2(1 - \hat{\phi}(z, \alpha)) \frac{d\hat{\phi}(z, \alpha)}{d(-z_i)}\right) \hat{p}(\max\{z_i, z_{-i}\})}_{\text{Market size}} - \underbrace{\left(E_{\phi}(\hat{\phi}, \alpha) \frac{d\hat{\phi}(z, \alpha)}{d(-z_i)}\right)}_{\text{Cost}}$$

$$+ \underbrace{\hat{\phi}(z, \alpha)(2 - \hat{\phi}(z, \alpha)) \left(\frac{d\hat{p}(\max\{z_i, z_{-i}\})}{d(-z_i)} + \frac{d\hat{p}(\max\{z_i, z_{-i}\})}{d\hat{\phi}(\cdot)} \frac{d\hat{\phi}(z, \alpha)}{d(-z_i)}\right)}_{\text{Competition}} = \gamma_{(-z)}(z_i)$$

## Efficient compatibility

$$- \underbrace{\left[\frac{dIC(z, \phi^*)}{d(-z)} + \frac{dPC(z, \phi^*)}{d(-z)}\right]}_{\text{Matching}} = \gamma_{(-z)}(z)$$

## Proposition

*With decreasing returns of standardization, the symmetric equilibrium where firms choose a positive level of product compatibility is characterized with excess compatibility.*

# Conclusion

## Take away

- *The incentives to inform consumers depend on the product design that shapes the intensity of competition in the market.*
- *The growth of online media has reduced the cost of reaching consumers  $\alpha \uparrow$ .*
  - *With better informed markets higher incentives to make products compatible with the rival.*

## Further research

- ① Active Consumers. Introduction of search behavior and shopping costs.
- ② Price discrimination (bundled prices).
- ③ Consumers are informed about the existence of products. Advertising informs only about prices.