A Question to the Consumer

- Monthly time spent on search: 138 mm hours
- Are you using more or fewer sites when doing product research online compared to last year? (a study done by ExpoTV.com)
  - Diverse responses
    - I use just as many sites as often as I did last year.
    - Definitely more.
    - ...I actually use fewer sites than I used to for product research.
  - How informative, easiness
What Happens During Information Search?

Expected Value

\( t \)
Research Questions

* When should the consumer stop searching for more information?
  * How does search informativeness matter?
  * How does search cost matter?

* Does the seller benefit from more or less consumer search?
  * What is the seller’s optimal pricing strategy?
  * What is his optimal information provision strategy?
The Model

• One consumer, one product, one seller

• The consumer learns some news on an aspect of “product fit” in each step of search, His “true” utility given the T product attributes is

\[ U = v + \sum_{i=1}^{T} x_i \]

where \( x_i \) equals \( z \) or \( -z \) with equal probability

• \( z \) can be different across attributes, \( x_i \) is “news” when checking attribute \( i \)
After inspecting $t$ attributes, the consumer’s expected utility is

$$u = v + \sum_{i=1}^{t} x_i + \sum_{i=t+1}^{T} E(x_i)$$

As $\varepsilon$ goes to zero and $T$ goes to infinity (an infinite mass of attributes), the process becomes a Brownian motion:

$$du = \sigma d\omega$$
The Consumer’s Problem

*x* At each point of time, consumer has to optimally choose among

1. Continue to gather more information at cost \( c \) per (unit of) attribute searched
2. Stop searching, buy the product
3. Stop searching, without buying the product

*x* Expected utility if keep on searching:

\[
V(u, t) = -cdt + EV(u + du, t + dt)
\]
Getting \( V(u) \)

- Taylor Expansion (plus Ito’s lemma):

\[
V(u, t) = -c \, dt + V(u, t) + V_u E(du) + V_t dt + \frac{1}{2} V_{uu} E[(du)^2] + V_{ut} E(du) \, dt.
\]

As \( E(du) = 0 \) and \( E[(du)^2] = \sigma^2 \, dt \) we have, dividing (1) by \( dt \),

\[
-c + V_t + \frac{\sigma^2}{2} V_{uu} = 0.
\]
Boundary Conditions

\[ V(\bar{U}) = \bar{U} \quad \text{and} \quad V'(\bar{U}) = 1, \quad V(\bar{U}) = 0 \quad \text{and} \quad V'(\bar{U}) = 0. \]

Intuition:

- Suppose \( V'(\bar{U}) < 1 \), then it would pay off to search more once reaching \( \bar{U} \) → a contradiction.

- Suppose \( V'(\bar{U}) > 1 \), then it would pay off to stop search prior to reaching \( \bar{U} \) → a contradiction.
The Value Function

\[ V(u) = \frac{c}{\sigma^2} u^2 + \frac{1}{2} u + \frac{\sigma^2}{16c} \]

No purchase

Keep searching

Purchase

\[ U = -\frac{\sigma^2}{4c} \]

\[ \bar{U} = \frac{\sigma^2}{4c} \]
The Optimal Stopping Rule

- The two bounds are symmetric around 0
- Starting point \( v \) does not affect the boundaries
- Purchase threshold increases with \( \sigma \) and decreases with \( c \)
Purchase Likelihood I

\[
\bar{U} - u(t_1)
\]

\[
u(t)
\]

\[
u(t_1)
\]

\[
0
\]
Formally, \( \Pr(u) = \frac{u - U}{U - U} \).

Prior to any search, \( \Pr(v) = \frac{2cv}{\sigma^2} + \frac{1}{2} \).

- If \( v < 0 \), having each attribute be more important increases the purchase likelihood (greater possibility of changing preferences).
- If \( v < 0 \), lower search cost also leads to a greater purchase likelihood (cheaper to gain information to reverse preferences).
- Results change if \( v > 0 \).
Optimal Price

Changing the price essentially changes the starting valuation, and hence changes the purchase likelihood \(\rightarrow\) linear demand (marginal cost is \(g\))

\[
p^* = \begin{cases} 
v - \frac{\sigma^2}{4c} = v - \overline{U}, & \text{if } v \geq g + 3\overline{U}; \\
\frac{v+g}{2} + \frac{\sigma^2}{8c} = \frac{1}{2}(v + g + \overline{U}), & \text{if } v < g + 3\overline{U}.
\end{cases}
\]
Maximum profit (in expectation) is

\[
\Pi(v) = \begin{cases} 
  v - g - U, & \text{if } v \geq g + 3U; \\
  \frac{(v-g+U)^2}{8U}, & \text{if } g + U \leq v < g + 3U.
\end{cases}
\]

- always increases with \( v \)
- increases with \( \bar{U} \) if \( v < g + \bar{U} \)
  - Low \( v \): increase in price dominates
  - High \( v \): decrease in purchase likelihood dominates
- Consumer surplus is half of the optimal profit:
  does not always increase with informativeness and
decrease with search cost
Extension 1: Independent Signals

$\sigma_t$ decreases in $t$ at a decreasing rate. $V(u,t)$ and purchase and no-purchase thresholds depend on the number of signals $t$ already checked.
Extension 2: Finite Mass of Attributes

When consumer is close to checking all possible attributes, it is not possible to raise expected value of the product substantially.
3. **Discounting:** If positive expected value of purchase, keeping on searching is more costly (more likely to purchase the products)

Conclusion: purchase threshold is closer to zero than exit threshold.

4. **Choosing the search intensity:** when consumer is closer to the purchase threshold, he searches more intensely, as discounting makes it more costly to keep on searching.

Conclusion: not to search intensively if far away from purchase, and search intensively when close to purchase.
Conclusions

- Parsimonious model of search for information
- Stopping rule obtained optimally as a function of search costs and information gained
- Implications for pricing – pricing affects consumer search behavior
- Extensions to signals for value of a product, finite mass of attributes, discounting, intensity of search
- Other questions:
  - Implications for social welfare: more search → more correct choices
  - Search over multiple alternatives (different from Gittins index problem)
  - Optimal provision of information if different attributes provide different amount of information
Thank You!