Optimal Search for Product Information

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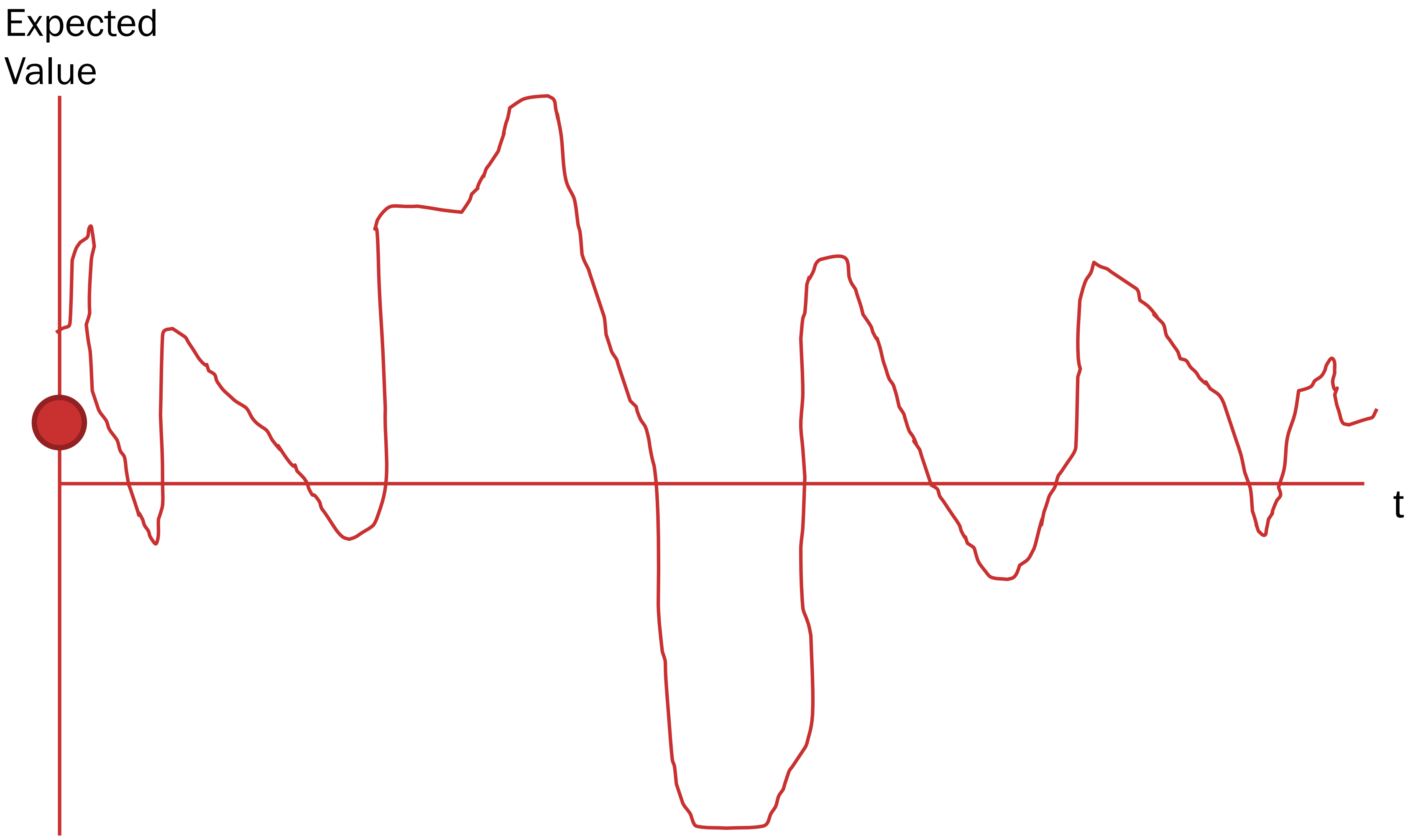
A Question to the Consumer

- 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?



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

Expected Utility through the Search Process

- 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 z 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

- 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

- 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,

$$-c + V_t + \frac{\sigma^2}{2} V_{uu} = 0.$$

Equals Zero

Boundary Conditions

$$V(\overline{U}) = \overline{U} \text{ and } V'(\overline{U}) = 1, \qquad V(\underline{U}) = 0 \text{ and } V'(\underline{U}) = 0.$$

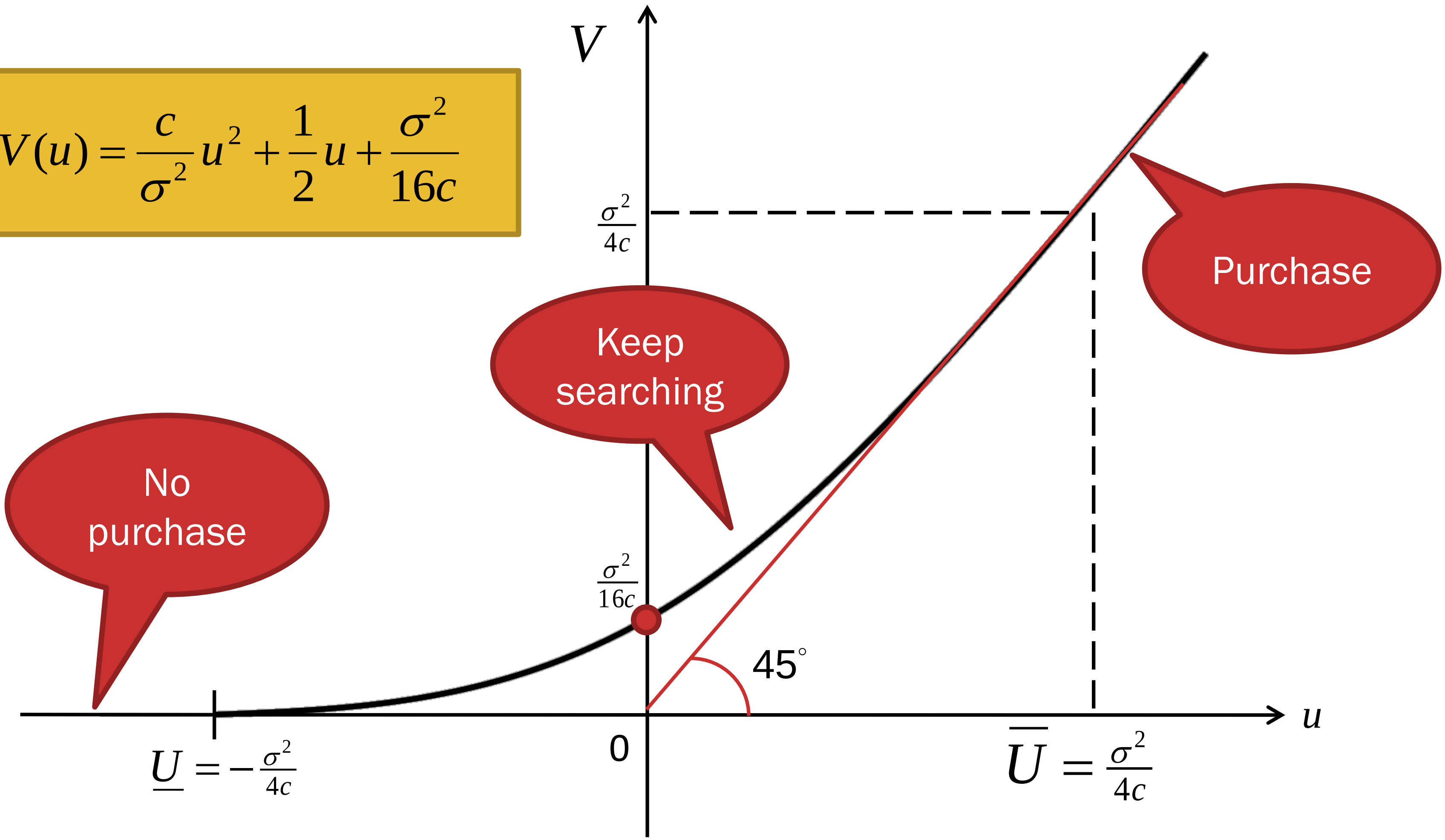
High contact condition

Intuition:

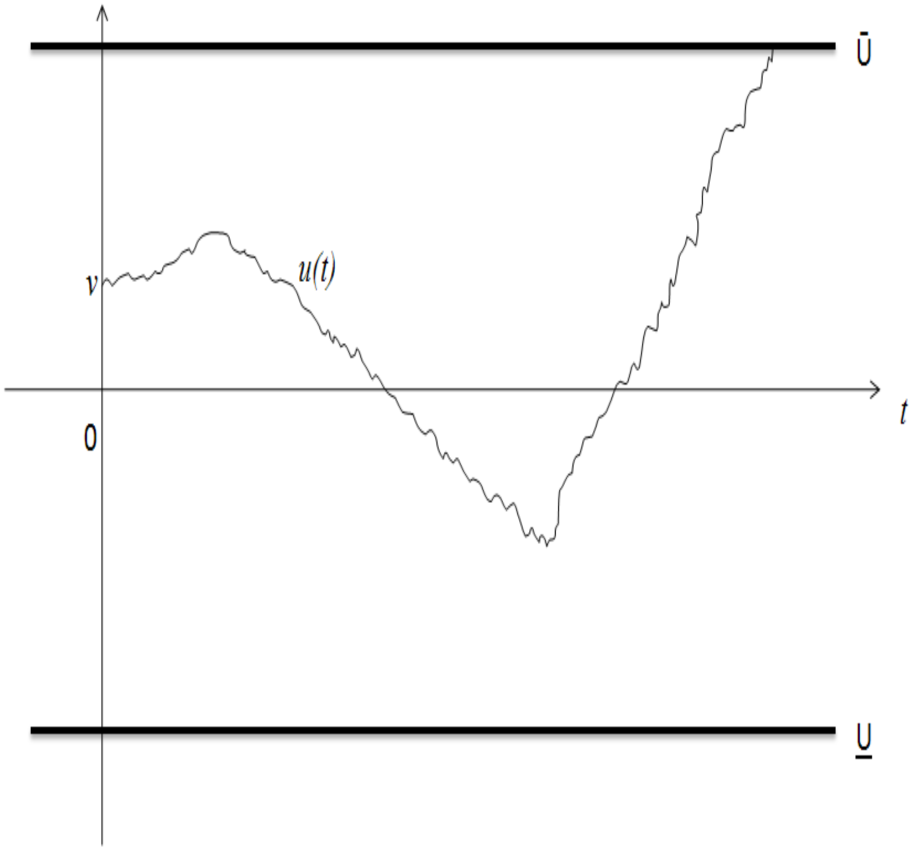
- suppose $V'(\bar{U})^{-}<1$, then it would pay off to search more once reaching Ū → a contradiction.
- Suppose $V'(\bar{U})^{-}>1$, then it would pay off to stop search prior to reaching Ū → a contradiction.

The Value Function

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

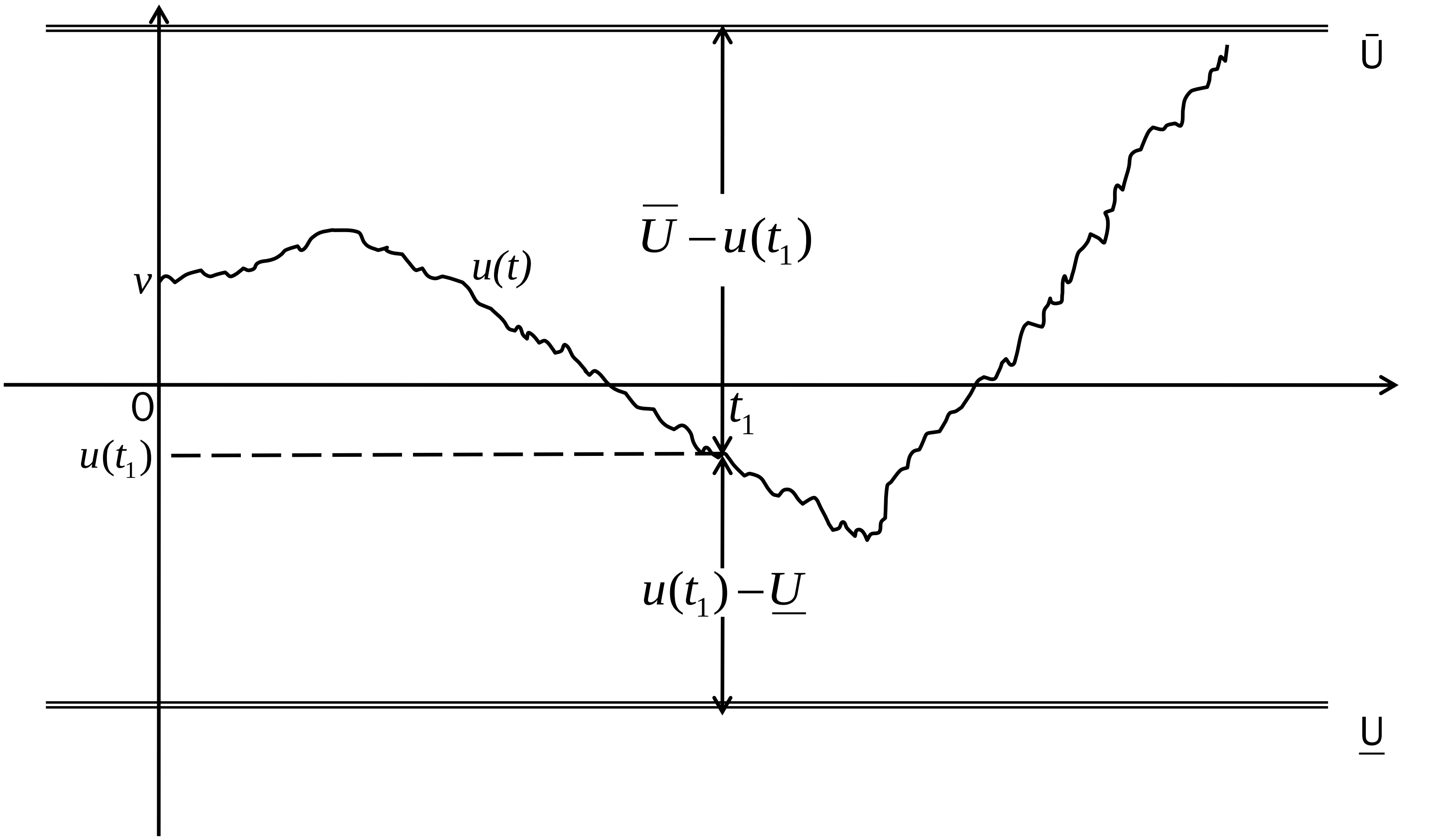


The Optimal Stopping Rule



- The two bounds are symmetric around 0
- Starting point *v* does not affect the boundaries
- Purchase threshold increases with σ and decreases with c

Purchase Likelihood I



Purchase Likelihood II

- Formally, $\Pr(u) = \dfrac{u - \underline{U}}{\overline{U} - \underline{U}}$
- Prior to any search, $\Pr(v) = \dfrac{2cv}{\sigma^2} + \dfrac{1}{2}$
  - 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 → linear demand (marginal cost is g)

No search

$$p^* = \begin{cases} v - \frac{\sigma^2}{4c} = v - \overline{U}, & \textit{if } v \geq g + 3\overline{U}; \\ \frac{v+g}{2} + \frac{\sigma^2}{8c} = \frac{1}{2}(v + g + \overline{U}), & \textit{if } v < g + 3\overline{U}. \end{cases}$$

Price if search is impossible

Price if set after search

Profit

- Maximum profit (in expectation) is

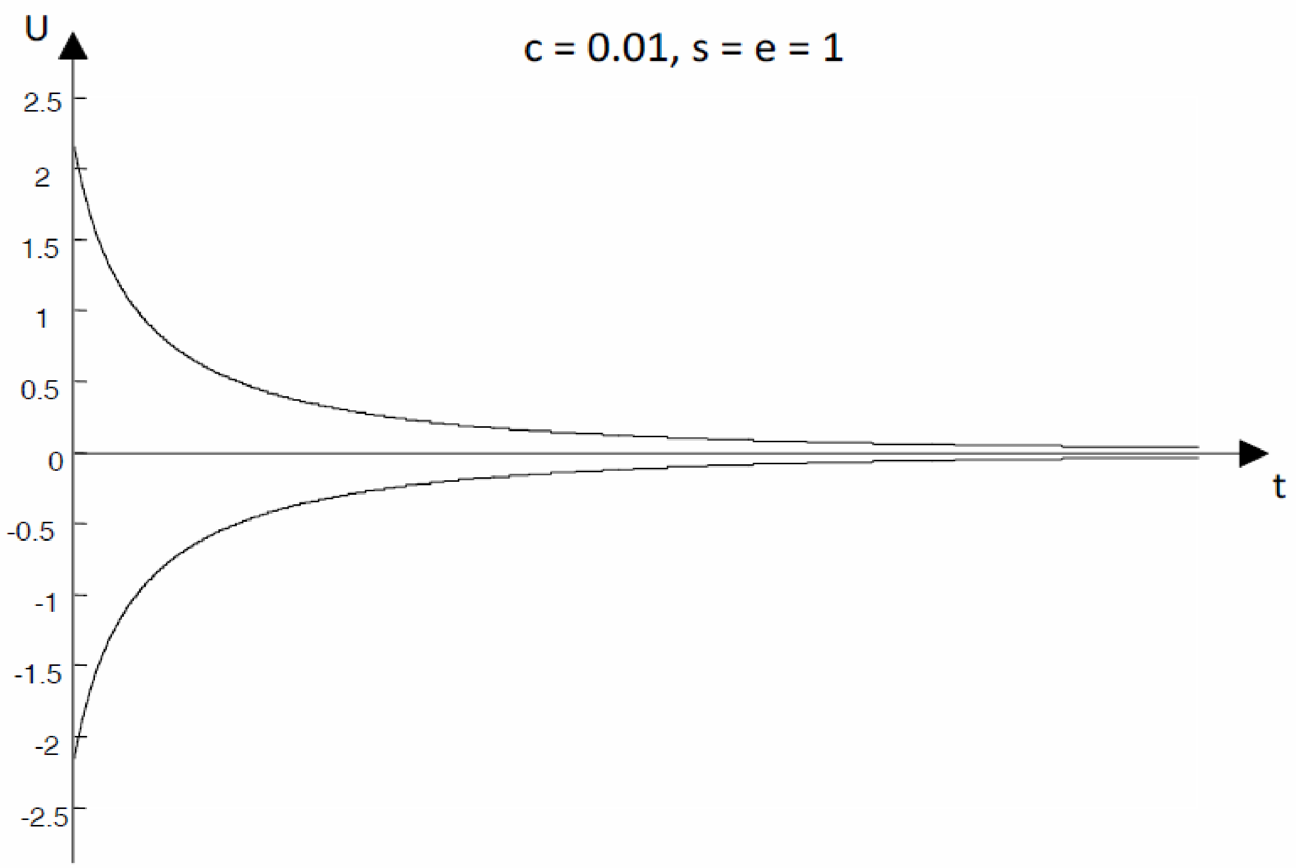
No search

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

  - 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

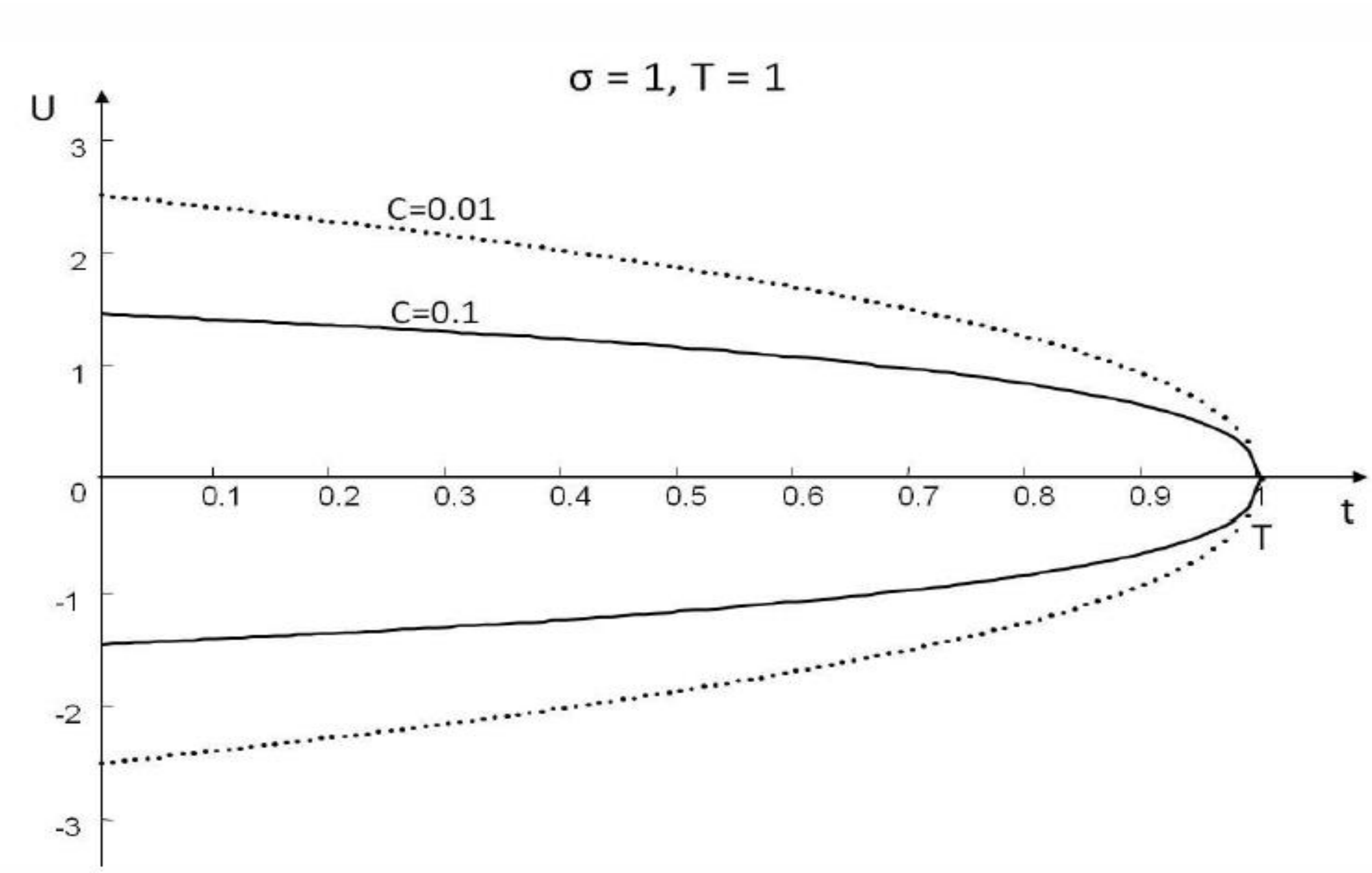
Extension 1: Independent Signals

σ_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



Other Extensions

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!