Information Economics

Past, Future, and Why

Ling-Chieh Kung

Department of Information Management
National Taiwan University

Road map

- **Review of this semester**.
- Future directions.
- What and why for scientific research.

What was in the syllabus?

- This is **Information Economics**, NOT **Information Economy**.
  - We do not put emphasis on IT, IS, information goods, etc.
  - We focus on **information**.
- We focus on the **economics of information**.
  - How people behave with different information?
  - What is the value of information?
  - What information to acquire? How?
  - What are the implications on business and economy?
- **Information asymmetry** is particularly important.

Why information asymmetry?

- The world is **decentralized**.
  - Especially systems consisting of multiple decision makers.
- How to optimize (or at least improve) a decentralized system?
  - We cannot control everyone directly.
  - We can only **induce** them to do something indirectly.
  - We can only **design rules**.
- We do **mechanism design**.
  - Issue 1: **Incentive**.
  - Issue 2: **Information**.

Information asymmetry

- The world is full of asymmetric information:
  - A consumer does not know a retailer's procurement cost.
  - A consumer does not know a product's quality.
  - A retailer does not know a consumer's valuation.
  - An instructor does not know how hard a student works.
- As information asymmetry results in inefficiency, we want to:
  - Analyze its impact. If possible, quantify it.
  - Decide whether it introduces driving forces for some phenomena.
  - Find a way to deal with it if it cannot be eliminated.
- This field is definitely fascinating. However:
  - We need to have some "**weapons**" to explore the world!

Before you enroll...

- Prerequisites:
  - Calculus.
  - Convex optimization.
  - Probability.
  - Game theory.
- This is an **academic methodology** course.
  - It is directly helpful if you are going to write a thesis with this research methodology.
  - It can be indirectly helpful for you to analyze the real world. However, we do not train you to do that in this course.

Topics

- Decentralized decision making.
- Adverse selection: screening.
- Adverse selection: signaling.
- Moral hazard.

Schedule: first half

Week	Topic
1	Optimization
2	Game theory
3	No class: Mid-autumn Festival
4	McGuire and Staelin (1983)
5	Pasternack (1985)
6	Two-type screening
7	Taylor and Xiao (2009)
8	Kung and Chen (2014)
9	Midterm exam

Schedule: second half

Week	Topic
10	Continuous-type screening
11	Signaling
12	Moral hazard
13	Desai (2001), Villas-Boas (1998)
14	Sundararajan (2004), Taylor and Xiao (2010)
15	Chen (2005), Kung and Chen (2011)
16	Review
17	Project presentations (1)
18	Project presentations (2)

Road map

- Review of this semester.
- **Future directions**.
- What and why for scientific research.

Topics not covered in this course

- Many materials in screening, signaling, and moral hazard are skipped.
- Auction.
- Double-sided information asymmetry.
- Multidimensional screening.
- Common agency.
- Dynamic mechanism design.
- Bounded rationality
  - Behavioral economics.
  - Behavioral finance.
  - Behavioral marketing.
  - Behavioral operations management.
  - Behavioral information systems.

Auction

- A seller sells **a single unit** of product to **a set of** consumers.
- Consumers have i.i.d. valuations, which is hidden to the seller.
- The best way to reveal the hidden valuations: **auction**!
- Various auction formats:
  - First-price ($p = \max_i\{b_i\}$) vs. second-price ($p = \max_{j:b_j<\max_i\{b_i\}}\{b_j\}$).

$$u_i(x_i) = \begin{cases} x_i - p & \text{if } b_i \geq b_j \quad \forall j \\ 0 & \text{otherwise} \end{cases}.$$

  - English (ascending) vs. Dutch (descending).
- Which format is revenue-maximizing?
- **Revenue equivalence theorem**: All the same!
  - Not true if consumers are risk averse.
  - Not true if valuations are correlated.
  - Not true if there are multiple units.

Double-sided information asymmetry

- A seller sells a product to a consumer.
- It was assumed in this course that exactly one of the following is true:
  - The consumer privately knows the **willingness-to-pay**.
  - The seller privately knows her/his **production cost**.
- What if they happen at the same time?
- Another example:
  - The consumer privately knows her/his **degree of risk aversion**.
  - The seller privately knows the **product quality**.
- Is a warranty offer a screening tool or a signaling tool?

Multidimensional screening

- An agent may have multiple sources of hidden information.
- For example, a consumer may have hidden valuations for two products.

$$u(\theta_1, \theta_2) = (\theta_1 q_1 - p_1)^+ + (\theta_2 q_2 - p_2)^+.$$

- A seller may **bundle** the two products:

$$u(\theta_1, \theta_2) = (\theta_1 q_1 + \theta_2 q_2 - p_{\text{bundle}})^+.$$

- Which strategy is optimal?
  - Selling two products.
  - Selling only a bundle.
  - Selling two products and a bundle.
  - Selling one product and a bundle.
- What if there are more than two products?
- What if valuations are correlated?

Common agency

- When one company hires a salesperson, there is an IR constraint:

$$\mathbb{E}\left[\alpha(\theta) + \beta(\theta)x - \frac{1}{2}a^2\right] \geq \bar{u},$$

  where $\bar{u}$ is the salesperson's **outside option**.
- If two companies compete in hiring the salesperson:

$$\mathbb{E}\left[\alpha_1(\theta) + \beta_1(\theta)x - \frac{1}{2}a^2\right] \geq \mathbb{E}\left[\alpha_2(\theta) + \beta_2(\theta)x - \frac{1}{2}a^2\right]$$

  and vice versa.
- Similar situations:
  - Two firms competes in quantity discounts.
  - Two firms competes in warranty offers.

Dynamic mechanism design

- When a manufacturer knows a retailer's forecasting accuracy, it screens the retailer's private demand signal.
- What if the accuracy is also hidden?
  - Two-stage screening: accuracy and then signal.
  - Stage 2: Knowing the accuracy, offering a **menu of contracts**.
  - Stage 1: Offering a **menu of menus**.
- When a principal and an agent sign contracts **repeatedly**:
  - In each period, the principal may offer a menu to screen the agent's type.
  - **Static IC constraints** are not enough.
  - The agent has incentives to lie. Otherwise, she/he will have no informational advantage in the future.

Bounded rationality

- People are not always fully rational.
  - Consumers, salespeople, bidders, investors, etc.
- Researchers try to model **bounded rationality**.
- **Probabilistic choices**:
  - A buyer faces two products, which give her/him utilities u_1 and u_2.
  - Let $u_1 > u_2$. A fully rational buyer chooses product 1.
  - A boundedly rational buyer chooses product 1 with probability

$$\frac{e^{ru_1}}{e^{ru_1} + e^{ru_2}},$$

    where $r \geq 0$ is the degree of rationality (larger r means more rational).
- Another example: **Anchoring effect/reference prices**:

$$\theta_t = \theta_{t-1} + \alpha(p_t - p_{t-1}).$$

- Emerging fields: behavioral economics/finance/marketing/OM/IS.

Emerging issues

- Whenever there is a **new business model**, there is a chance.
- New business models are often driven by **new technology**.
  - Physical channels vs. online channels.
  - Online display advertisement.
  - Information goods, data plans, and could services.
  - Probabilistic goods (opaque channels).
  - Group buying.
  - In-store referrals.
  - C2C marketplace and sharing economy.
  - P2P file sharing, P2P lending, and P2P information sharing.
  - Crowd-sourcing and crowd-financing.
  - Micro-financing.
  - Data economy.
- There are just too many things to study!

Economics of Information Systems

- These issues are in the field of **economics of information systems**.
  - The intersection of economics, marketing, finance, operations management, and information management.
- For each new business model driven by modern information technologies, people ask:
  - **How** to be successful?
  - **Why** are they successful?
- What researchers typically answer is **why**, not **how**.
- Take the game-theoretic modeling approach as an example:
  - Models are "simplified."
  - Assumptions are needed.
  - Equilibrium outcomes (prices, stocking levels, etc.) cannot be applied.
- Why do people do this?
- Why do we teach this (in an engineering department/business school)?

Road map

- Review of this semester.
- Future directions.
- **What and why for scientific research**.

Scientific research

- This course teaches you how to do research.
  - In particular, **scientific research**.
  - Though some people do not consider social sciences as science.
- This course is special (if not weird).
  - This is not a typical course is a department of Information Management or Industrial Engineering.
  - There are even not many similar courses in a business school.
  - This course talks about **science**, not **engineering** or **management**.
- What is scientific research? What is science?
- What is the value generated by scientific research?
  - If the results cannot be applied in practice?

Science, engineering, and management

- What are the differences among science, engineering, and management?
- In my opinion:
  - Engineering is to **solve problems**.
  - Management is to **make decisions**.
  - Science is to **identify factors**.
- Decision making is based on solutions and factors.
  - And intuitions, experiences, observations, connections, etc.
  - "Management is art and cannot be taught."
- Let's talk more about engineering and science.

Engineering and management research

- One kind of engineering research: **optimization**.
  - For a given problem with well-defined constrains and objective functions, design an algorithm to find an **optimal solution**.
  - E.g., to make a bridge the most stable.
- One kind of engineering research: **data analytics**.
  - For a set of data, design an algorithm to **minimize the time** to complete some calculations. E.g., apriori for frequent patterns.
  - For a set of data, design an algorithm to **minimize prediction errors**. E.g., regression and support vector machine.
- One kind of management research: **data analytics**.
  - For a set of data, find **hidden facts** that were not aware of in the past.
  - E.g., the sales of one kind of candy is high before a typhoon.

Scientific research

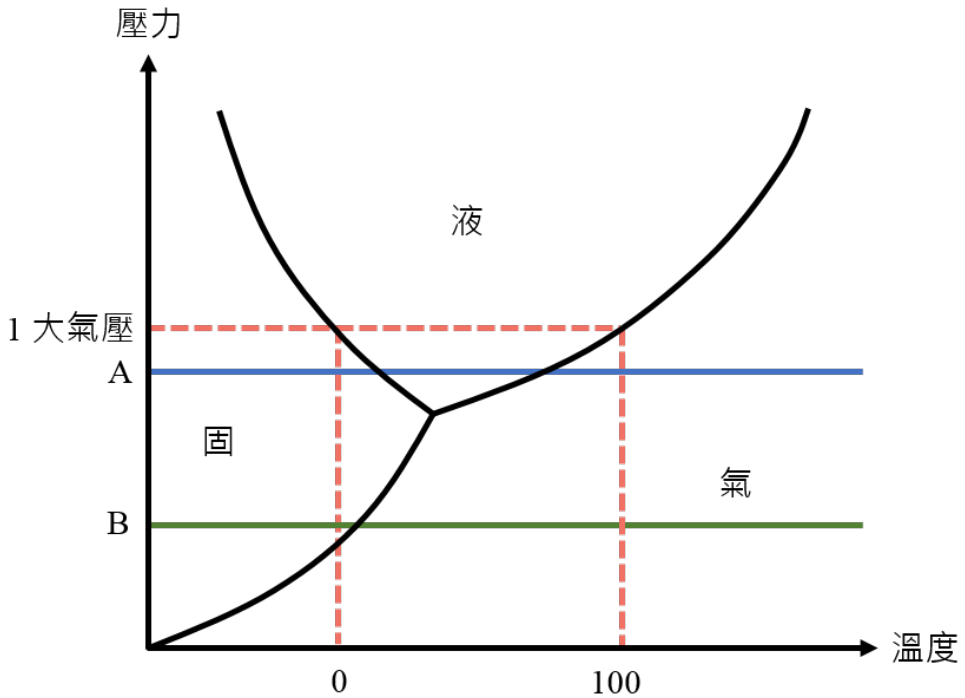
- Scientific research aims to **identify factors** that explain phenomena.
- Recall your junior high school textbook:
  - Step 1: Observing a phenomenon in practice.
  - Step 2: Make a hypothesis for possible reasons.
  - Step 3: Verify or reject the hypothesis (through, e.g., experiments).
  - Step 4: Let the society examine the results.
  - Step 5: Convert a hypothesis into a "theorem."
- Some examples in this semester:
  - Why does a manufacturer delegate to a retailer?
  - Why is a return contract popular in a channel?
  - Why is there a minimum fee for usage-based information goods pricing?
- In many cases, the reasons proposed by the studies are **insignificant**.
  - Is it really useful?

Insignificant factors

- Consider the decision of whether to delegate to a retailer.
- Why doing so?
  - The retailer has good reputation.
  - The retailer is good at retailing.
  - The retailer can monitor the market or salespeople better.
  - The manufacturer just cannot reach the market.
  - The market competition is too intensive.
- Business people in practice care about **significant factors**.
- Scientists look for about **insignificant factors**.
- Why insignificant factors?
  - Because they are nontrivial and surprising.
  - Because they expands humans' knowledge.
- People can be knowledge-seeking with no reason.
  - But are insignificant factors "useful"?

Insignificant factors

- Why does water become air?
  - The temperature increases.
  - The air pressure decreases.
- Without knowing that air pressure also affects the boiling point, we cannot explain phenomena on high mountains (and find ways to survive).
- Knowing significant factors helps you in **usual cases**; knowing insignificant factors helps you in **special cases**.



(Figure credit: Ho Ho)

Scientific research

- There are at least three kinds of scientific research in social sciences: theoretical, empirical, and qualitative research.
- **Qualitative**:
  - Do not use any mathematical model or numerical data.
  - E.g., pure logical reasoning and case studies.
- **Empirical** (data-driven):
  - Using statistical or econometric methods to identify factors for outcomes.
  - E.g., a regression-based study reporting significant independent variables.
- **Theoretical** (model-based):
  - Using game-theoretic models to describe the interaction of a set of decision makers in a system.
  - Characterizing equilibrium outcomes to predict their decisions.
  - Identifying conditions for a kind of equilibrium to (maybe uniquely) exist.
  - E.g., all those things we did in this course.

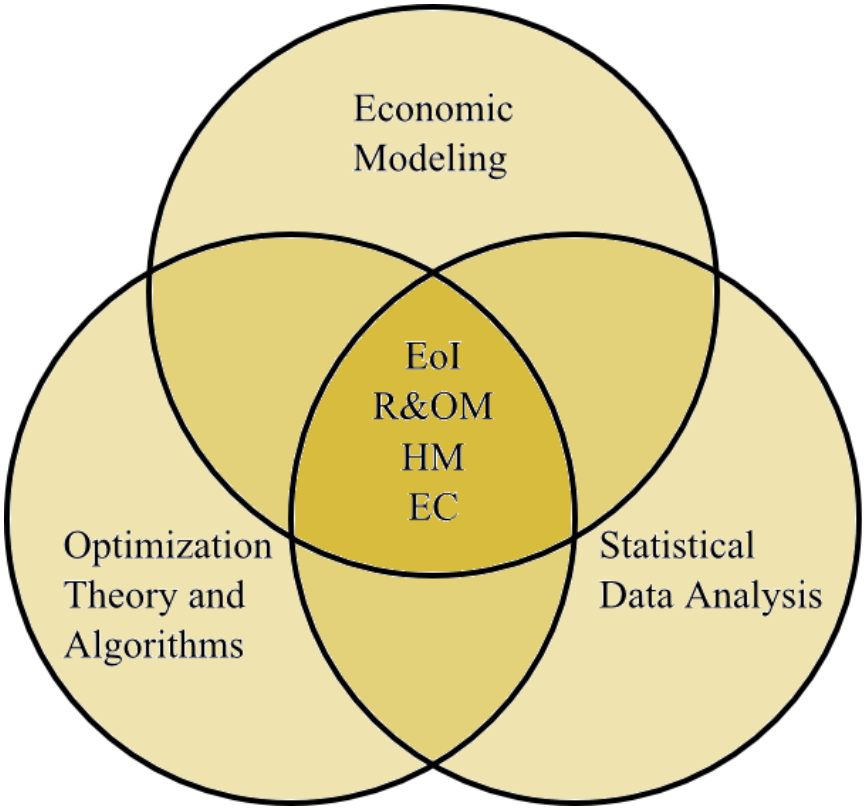
Theoretical studies

- Theoretical studies need assumptions.
  - To make the model **tractible**.
  - To allow researchers **isolate the factor** of interest.
- Assumptions can be dangerous.
  - Conclusions drawn from an **oversimplified model** are useless.
  - "Something is true for all cases" may be due to a **too narrow focus**.
- Still, theoretical studies are needed.
  - Pure logical reasoning can be too hard and controversial.
  - Case studies are not enough: Some people do not tell the truth.
  - Empirical studies are not enough: Some data are not available.
- Theoretical studies can **make predictions** (qualitatively).
  - It may be bad to delegate to a better-forecasting retailer.
  - Delegating to a retailer will enlarge quality difference in a product line.
  - Monitoring sales effort is more critical than monitoring market condition, even if they can be done only indirectly.

Management through science and engineering

- Management is to **make decisions**.
  - We need intuitions, experiences, observations, connections, etc.
  - Still, solutions and factors help.
- Therefore, we need engineering and science.
  - Engineering is to **solve problems**.
  - Science is to **identify factors**.
- Two important engineering methodologies: optimization and statistics.
- One important scientific methodology: theoretical modeling.
- That is why...

Management through science and engineering



→

Information
Economics and
Decision
Optimization

Objectives of this course

- In summary, what is the objective of this course?
  - To give you a tool for conducting **scientific research**.
  - To give you a tool for (business) **decision making**.
  - To make you a good researcher and practitioner.
- There may be one "side effect":
  - To make you "**think in a different way**."
- For example, after I started to work in this field:
  - I do not believe that (a large group of) people will collaborate selflessly.
  - I do not believe that (a large group of) students will voluntarily make a public lobby clean.
  - *Freakonomics*: Morals talk about an ideal world world; economics talks about the real world.
  - I can consider policy issues (e.g., tuition, examination, elections, etc.) more deeply (or at least for a longer time).
- We may become more ready to debate for rules, policies, and laws.
- We may become more ready to **participate in our society**.

My expectations and suggestions

- Sooner or later you will leave the school. Please:
  - **Identify factors** for phenomena.
  - Care more about the **society**.
  - **Keep learning**.
- To do so, enhance two abilities before you leave the school:
  - **English** (and/or some other languages).
  - **Mathematics**.