Markets & Information

Networks, Crowds, and Markets
Chapter 22

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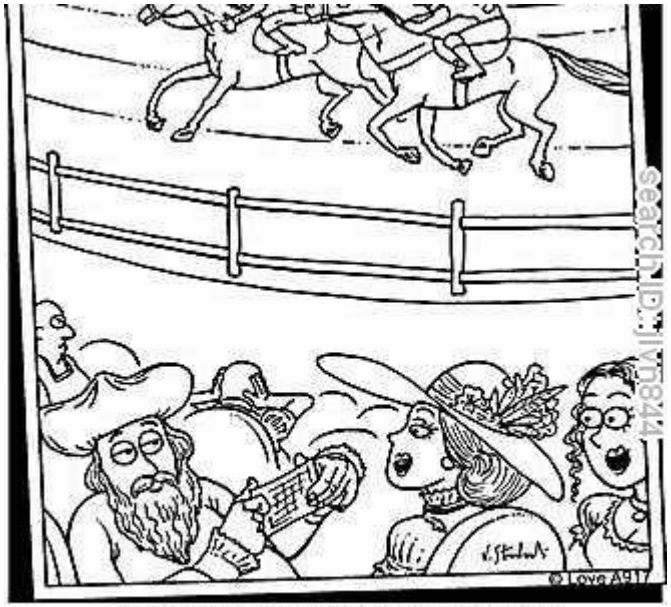

Before becoming the legend that he is today, Nostradamus first enjoyed a pretty good living at the tracks.

Outline

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- Introduction
- **Markets with Exogenous Events**
  - Horse Races, Bettings, and Beliefs
  - Wisdom of the Crowds
  - Prediction Markets & Stock Markets
- **Markets with Endogenous Events**
  - Market of Lemons
  - Asymmetric information
  - Signaling Quality
  - Quality Uncertainty On-Line

Introduction
aka „Definitions“

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Exogenous Markets

Decisions do not affect the outcome of the contract.

- Prediction markets
- Horse Races

Endogenous markets

Underlying events are affected by the decisions made (s. Braess‘s Paradox, Information cascades)

- Used car markets

Horse Races, Bettings and Beliefs
Definitions

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- w := Wealth distributed among bets
- r := Fraction of w bet to A
- $(1\text{-}r)$:= Fraction of w bat to B
- Horse „A“
  - a := Win probability (subjective)
  - o_A := Odds for A
  - rwo_A := Monetary payoff for A win
- Horse „B“
  - b := Win probability (subjective)
  - o_B := Odds for B
  - $(1\text{-}r)wo_B$:= Monetary payoff for B win

Horse Races, Bettings and Beliefs
Utility functions

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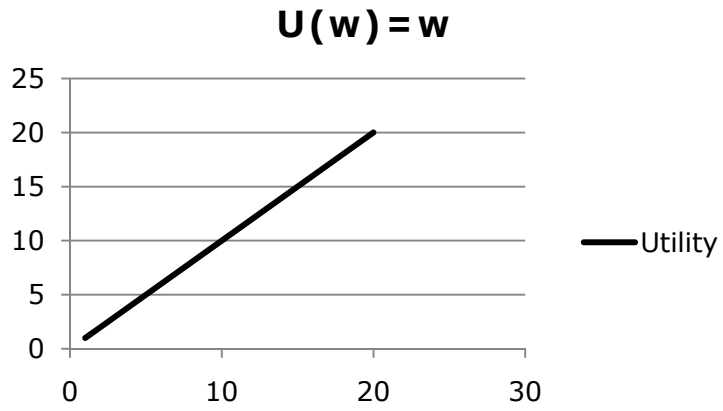
Utility Function U(w) ⇔ Attitude towards Risk

Simplest idea: Linear functions – i.e. U(w) = w

More general U(w) = $\alpha w+\beta$

Idea: more wealth := more Utility, regardless of the actual absolute wealth

Realistic?



Horse Races, Bettings and Beliefs
Fair gamble-Test

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Fair gamble

-> Expected value of wealth AFTER the gamble = current wealth

$$\frac{1}{2}\cdot(2w)+\frac{1}{2}\cdot 0 = w$$

Utility of accepting the gamble: $\frac{1}{2}U(2w)+\frac{1}{2}U(0)=\frac{1}{2}\cdot(2w)+\frac{1}{2}\cdot 0 = w$

Utility of passing: $U(w)=w$

$\Rightarrow$Investor is indifferent between accepting and passing the gamble

$\Rightarrow$… indifferent whether to posses $2,000,000 or end up at $0

Again: Realistic? ☺

Horse Races, Bettings and Beliefs
Fair gamble-Test

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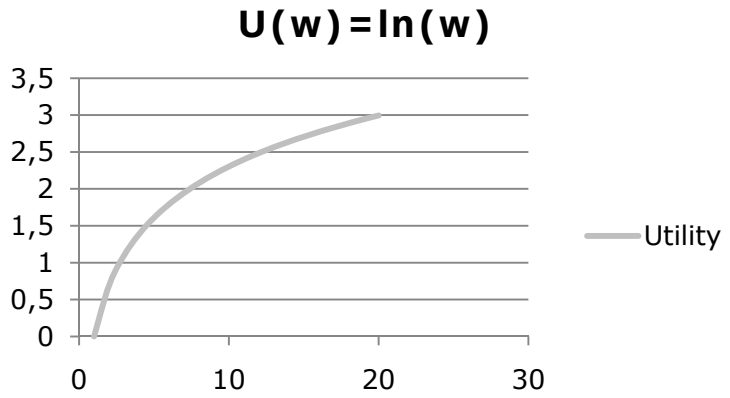
Better Idea: Utility function with decreasing growth

$$U(w) = w^{1/2}$$

$$U(w) = \ln(w)$$



Again: *Fair gamble*-test

Utility of accepting: $\frac{1}{2}U(2w) + \frac{1}{2}U(w \to 0) = \frac{1}{2}\ln(2w) + \frac{1}{2}\lim_{x \to 0}\ln(x) = -\infty$

Utility of passing: $U(w) = \ln(w)$

Horse Races, Bettings and Beliefs
Optimal Strategy

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Strategy := Distribution of wealth between two bets (A and B)

Remember: An *optimal strategy* is such, that maximizes the player's utility.

$$a\ln(rwo_A)+(1-a)\ln((1-r)wo_B)$$
$$=\boxed{a\ln(r)+(1-a)\ln(1-r)}+\boxed{a\ln(wo_A)+(1-a)\ln(wo_B)}$$
$$\Rightarrow a\ln(r)+(1-a)\ln(1-r)\overset{!}{=}MAX$$
$$\Rightarrow \frac{a}{r}-\frac{1-a}{1-r}=0$$
$$\Rightarrow a=r$$

Optimal strategy is to bet your beliefs

Wisdom of Crowds
Aggreate Beliefs

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- Where are the odds gone?

⇒Determinated by the aggregate Beliefs

⇒The race-track wants to break even in either case

Total amount bet on A: $\sum_{n=1..N} a_n w_n$

Total amount bet on B: $\sum_{n=1..N} b_n w_n$

Total payoff if A wins: $o_A \sum_{n=1..N} a_n w_n$

Total payoff if B wins: $o_B \sum_{n=1..N} b_n w_n$

Wisdom of Crowds
Aggreate Beliefs

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$$w = \sum_{n=1..N} w_n$$

In order to break even : payoffs = bets

$$o_A \sum_{n=1..N} a_n w_n = w \qquad o_B \sum_{n=1..N} b_n w_n = w$$

$$\sum_{n=1..N} \frac{a_n w_n}{w} = o_A^{-1} \qquad \sum_{n=1..N} \frac{b_n w_n}{w} = o_B^{-1}$$

$$f_n = \frac{w_n}{w} \qquad f_n = \frac{w_n}{w}$$

$$\sum_{n=1..N} a_n f_n = o_A^{-1} \qquad \sum_{n=1..N} b_n f_n = o_B^{-1}$$

$p_A = o_A^{-1} \equiv$ "price of a dollar" for the event that A wins (state price for "A wins")

$p_B = o_B^{-1} \equiv$ "price of a dollar" for the event that B wins (state price for "B wins")

Wisdom of Crowds
Interpretation

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1) If $a_n = a$ for all n => $p_A = a$
   => If everyone agrees in the probability a, it reflects exactly the market price

2) State prices are weighted averages of the bettors‘ beliefs

3) More wealth = more influence to the market

4) For a crowd, which is big enough:

The aggregated weighted beliefs of the crowd converges to the true probability of A to win

=

„Wisdom of Crowds“

Limitations: 1) opinions are independent (symmetric information distribution)

2) wealth shares are equal

Prediction & Stock Markets
… of horses and markets

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Prediction markets

Example: Trading a $1 contract on win of elections of the U.S. presidential elections

Difference to horse bets:

- „Bettors" trade their contracts with each other, rather than with an institutional „race-track"
- Interpretation of the state prices: The price of one-dollar return in the event specified by the contract
- Wisdom of the Crowds proven experimentally

Prediction & Stock Markets
… of horses and markets

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Stock markets

Difference to horse bets:

- No clear mutual state prices
- No „odds" in real sense: the payoffs are determinated by the value of the stock in each state

Prediction & Stock Markets
… of horses and markets

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Very simple example

Two companies, two states:

State 1 (s_1): „Company 1 does well, Company 2 does not“

- Company 1 is worth $1
- Company 2 is worth $0

State 2 (s_2): „Company 2 does well, Company 1 does not“

- Company 1 is worth $0
- Company 2 is worth $1

=> Same as horse races: stocks are equivalent to contracts, prices are market probabilities

Prediction & Stock Markets
… of horses and markets

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Advanced example

Two companies, two states:

State 1 (s_1): „Company 1 does well, Company 2 **not quite well**"

- Company 1 is worth **$2**
- Company 2 is worth **$1**

State 2 (s_2): „Company 2 does well, Company 1 **not quite well**"

- Company 1 is worth **$1**
- Company 2 is worth **$2**

Prediction & Stock Markets
… of horses and markets

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Advanced example

p_x:=state price for state x

v_y:=value of a share of company y

Price of a share for Company 1 = value of the future worth of the company.

$$v_1 = 2p_1 + 1p_2$$
$$v_2 = 1p_1 + 2p_2$$
$$\Leftrightarrow$$
$$p_1 = \frac{2v_1 - v_2}{3}$$
$$p_2 = \frac{2v_2 - v_1}{3}$$

Problem: We need enough information to calculate prices so that the equitation systems yields a solution => The set of stocks has to be „rich enough“

Markets with Endogenous Events

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Endogenous := The outcome of the event depends on the actions the individuals take

Examples:

- Joining a social network
- Market of used cars

Common theme:

Self-fulfilling expectations

Markets with Endogenous Events
Self-fulfilling expectations

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Example: Social network joining

Everyone expects the payoff of joining a social network to be low

⇒Barely anyone joins the network

⇒The payoff is low indeed

Example: Market for used cars

Everyone expects to be only low-quality cars on the market

⇒No potential buyer is willing to pay a price of a good car

⇒No potential seller of a good car is willing to sell for a low price

⇒Only low-quality cars will be on the market

Markets with Endogenous Events
Asymmetric information

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Example: Market for used cars

An important difference in this case: Asymmetric information distribution among (prospective) buyers and sellers

A seller knows more about the quality of the car than the prospective buyer

Markets with Endogenous Events
The Market of Lemons

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Example: Market for used cars

Simplification: There are only good and bad cars on the market

v_S^+ := seller's value of a good car = 10

v_S^- := seller's value of a bad car = 4

v_B^+ := buyer's value of a good car = 12

v_B^- := buyer's value of a bad car = 6

p^+ := price of a good car

p^- := price of a bad car

g := fraction of good cars

h := fraction of good cars for sale

Markets with Endogenous Events
The Market of Lemons

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Example: Market for used cars

In a market with <u>symmetric</u> information:

$v_S^+ < p^+ < v_B^+$

$v_S^- < p^- < v_B^-$

In a market with <u>asymmetric</u> information:

$v_B^* = 12h+6(1-h) = 6+6h$

Markets with Endogenous Events
The Market of Lemons

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Example: Market for used cars

Self-fulfilling-expectations equilibria:

For h=g:

p* := a price at which all sellers would offer their cars for sell

$p^* = 6+6g \geq 10$

$\Rightarrow g \geq 2/3$

g = 2/3 : Critical point of an equilibrium in this value-setting

Markets with Endogenous Events
The Market of Lemons

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Advanced Example: Market for used cars with lemons

- There are good cars, bad cars and *lemons*
- There are more buyers than sellers
- Good cars: $v_S^+ = 10$, $v_B^+ = 12$
- Bad cars: $v_S^- = 4$, $v_B^- = 6$
- Lemons: $v_S^0 = v_B^0 = 0$

In a market with <u>symmetric</u> information:

All cars are sold at \$12 or \$6, buyers and sellers are indifferent to buy a lemon

Markets with Endogenous Events
The Market of Lemons

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Advanced Example: Market for used cars with lemons

In a market with asymmetric information:

Three candidates for equilibrium:

a) All cars are offered for sale

b) Only bad cars and lemons are offered for sale

c) Only lemons are offered for sale

Markets with Endogenous Events
The Market of Lemons

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Advanced Example: Market for used cars with lemons

a) All cars are offered for sale

$$p_B = \frac{12+6+0}{3} = 6$$

$\Rightarrow$ Price below sellers of good cars expectations

$\Rightarrow$ No good cars are offered for sale

$\Rightarrow$ No equilibrium

Markets with Endogenous Events
The Market of Lemons

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Advanced Example: Market for used cars with lemons

b) Only bad cars and lemons are offered for sale

$$p_B = \frac{6+0}{2} = 3$$

$\Rightarrow$ Price below sellers of bad cars expectations

$\Rightarrow$ Only lemons are offered for sale

$\Rightarrow$ No equilibrium

Markets with Endogenous Events
The Market of Lemons

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Advanced Example: Market for used cars with lemons

c) Only lemons are offered for sale

$$p_B = 0$$

$\Rightarrow$ An equilibrium, but worthless

Conclusion

a) leads to b), which leads to c)

$\Rightarrow$ Complete market failure

Markets with Endogenous Events

The Market of Lemons - Summary

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Characteristics of the lemon market:

(i) Items of different qualities

(ii) For each quality, the buyer's value is at last as high as seller's value => market succeeds in symmetric information

(iii) Asymmetric information: Only one side of transaction actually knows about the quality

(iv) Following from (iii): all items are priced with the same value, items priced bellow their seller's value won't be put for sale

Asymmetric information in markets

Labor market

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The Labor Market

(i) Different qualities of workers: productive and unproductive

(ii) Employers hire employers at wages appropriate to their quality, if they could determinate it

(iii) Asymmetric information: An employees know more about their qualities than the employers

(iv) Following from (iii): wages can‘t directly depend on employee‘s quality => a uniform wage is offered to all potential workers, workers with higher wage expectations will leave the market into self-employment

Asymmetric information in markets

Labor market

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The Labor Market

Assumptions:

- Productive workers generate a revenue of $80.000, but may choose to produce an alternate income of $55.000 by being self-employed
- Unproductive workers‘ generated revenue is $40.000, their alternate income through self-employment is $25.000

In *symmetric information*, a company would pay $55.000 to $80.000 to productive employees and $25.000 - $40.000 to unproductive ones

Asymetric information in markets
Labor market – asymmetric information

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The Labor Market

Assumptions:

- Productive workers generate a revenue of $80.000, but may choose to produce an alternate income of $55.000 by being self-employed
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In *asymmetric information*, a company has to offer a wage of *w* based upon it‘s expectations to the distribution of the two types of job-seekers on the market

Asymetric information in markets
Labor market – asymmetric information

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In a*symmetric information* market:

Assumption: ½ of the workers are productive, ½ are not

Expectation: All workers are on the market

$$w = \frac{\$40.000 + \$80.000}{2} = \$60.000$$ ⇒All employees get hired

Expectation: Only unproductive workers are on the market

$$w = \$40.000$$ ⇒Only unproductive employees get hired

Both are self-fulfilling-expectation equilibria, so far so good

Asymetric information in markets
Labor market – asymmetric information

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In a*symmetric information* market:

Assumption: ¼ of the workers are productive, ¾ are not

Is there an equilibrium?

Expectation: All workers are on the market

$$w = \frac{3}{4} \cdot \$40.000 + \frac{1}{4} \cdot \$80.000 = \$50.000$$

⇒Only unproductive employees get hired

⇒There is no self-fulfilling-expectation equilibrium, productive workers are driven out of the market by the high frequency of the unproductive ones

Signaling Quality

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Signal := An approach to break the information asymmetry

The trader being in information advantage „signals" a bit of his information to the other trader.

Signals are more expensive to traders of „bad" goods

- Used-cars market:
  - TÜV-Certificates
  - Test drives
  - Guarantees
- Labor market:
  - Education certificates as prove of qualification
  - Education certificates as prove of effort-willingness

Quality Uncertainity On-Line

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Many Web-Sites for online commerce are motivated by considerations of asymmetric information and signaling

⇒**Reputation Systems (eBay)**

- An eBay-bidder is uncertain about seller‘s fairness
- If the risk to „buy a lemon“ is too high, the bidders won‘t bid a price high enough for the sellers of a good items, the market would fail

Solution: **Reputation as signal for quality**

„Expensive“ to obtain, but much cheaper for good seller than for a bad one.

⇒**Ad Quality in Keywords-Based Advertising**

- An ad „looking good“, but pointing to an uninteresting landing page would generate a high click-rate in the short term, but might decrease the general click-rate in the long term.

Thank you!

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Questions?