Understanding Financial Crises: the Contribution of Experimental Economics

Frank Heinemann

Technische Universität Berlin

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Structure

1. **Phases of Financial Crises**
2. **Bubbles and Crashes: rational behavior?**
3. **Herding: limited levels of reasoning?**
4. **Bank Runs: measures of prevention**
5. **Refinancing Debt: a coordination game**

   5.1. Predictions and comparative statics

   5.2. Recommendations for individual behavior

   5.3. Effects of providing information

   5.4. Cheap talk

   5.5. Welfare Effects of Public Information

   5.6. Sequential decisions
6. **The Power of Sunspots**
7. **Conclusions**

1. Phases of Financial Crises

Minsky (1975)

1. **Trigger**: exogenous event, e.g. new technology, financial market innovation
2. **Boom**: new opportunities for investing let profits rise.
3. **Credit expansion**: banks are transforming short-term deposits into long-term credits.
4. **Destabilising speculation**: **price bubbles, herding**.

   => overinvestment
5. **Crash**: profits do not live up to previous expecations, banks write off part of the outstanding debt.

   when does a bubble collapse?

Phases of Financial Crises

5. **Crash**: profits do not live up to previous expecations, banks write off part of the otstanding debts.
6. **Reversal of capital flow**: depositors try to withdraw.
7. **Panic: panic sales (herding)** cause rapid decline in asset prices.
8. **Liquidity squeeze**: banks compete for scarce liquidity.

   Banks in need of refinancing, eventual illiquidity.
9. **Liquidity spirals**: banks sell long-term assets.

   => asset prices may fall below fundamental value.

   => **More banks go bust (contagion).**

Some phases can be tested in the laboratory!

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Experiments in economic research

Model theoretical predictions based on assumptions about behavior

Empirical test

in the field – dirty data (inhomogeneous situations: each crisis is different, private information unknown,…)

in the lab – good controll on causality and subjects' information

Experiment well-suited for testing fundamental assumptions of theories

2. Price bubbles

Rational Bubbles: equilibrium selection

Marimon & Sunder (1993, 1994), experiment with overlapping generations and 2 stationary equilibria:

Convergence to efficient equilibrium with bubbles.

Dynamics are in line with adaptive learning, contradict rational expectations.

Price bubbles

Under which conditions may we expect a bubble to arise?

Smith, Suchaneck, and Williams (Ecmta 1988): finite economy, subjects repeatedly trade an asset with an exogenously given fundamental value. Unique equilibrium: no trade, price = fundamental value.

Experiment reliably generates bubbles and crashes.

Dufwenberg et al. (AER 2005): If at least 1/3 of subjects are experienced (participated in the experiment before), bubbles do not ccur.

"Any time is different"

The Dotcom bubble is not likely to reappear, neither tulips or railway companies.

Under which conditions are bubbles likely to arise?

open question – latest experiments include frictions on and regulation of financial markets

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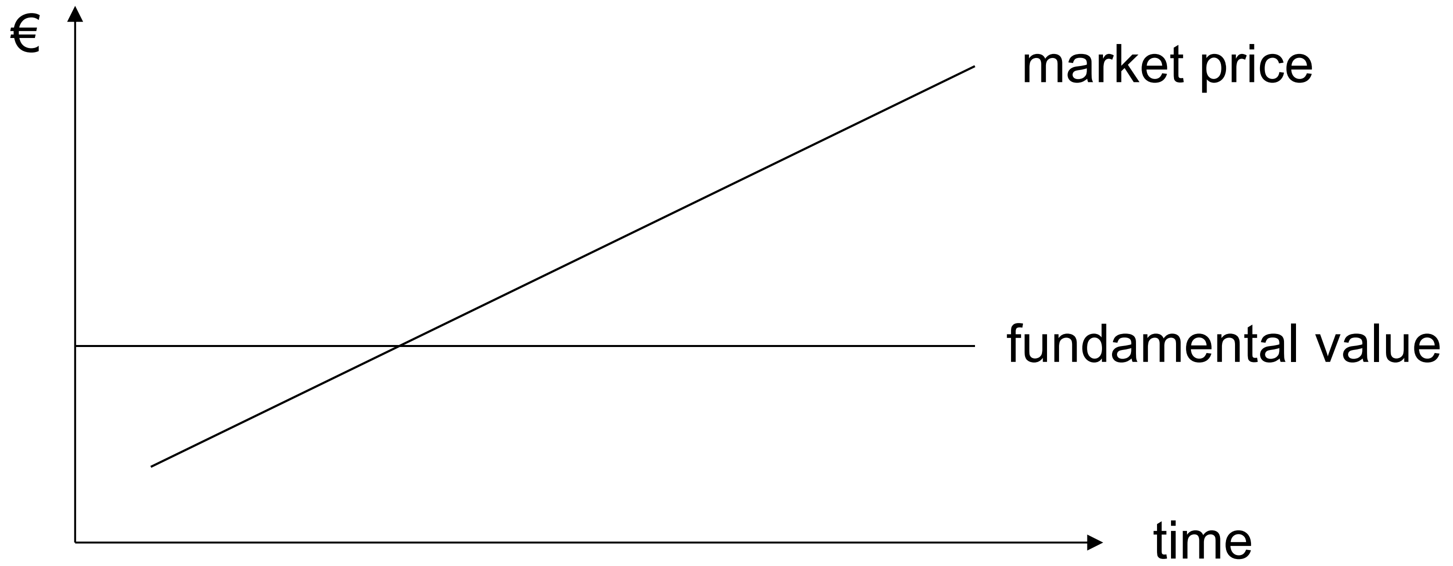
Bubbles and Crashes

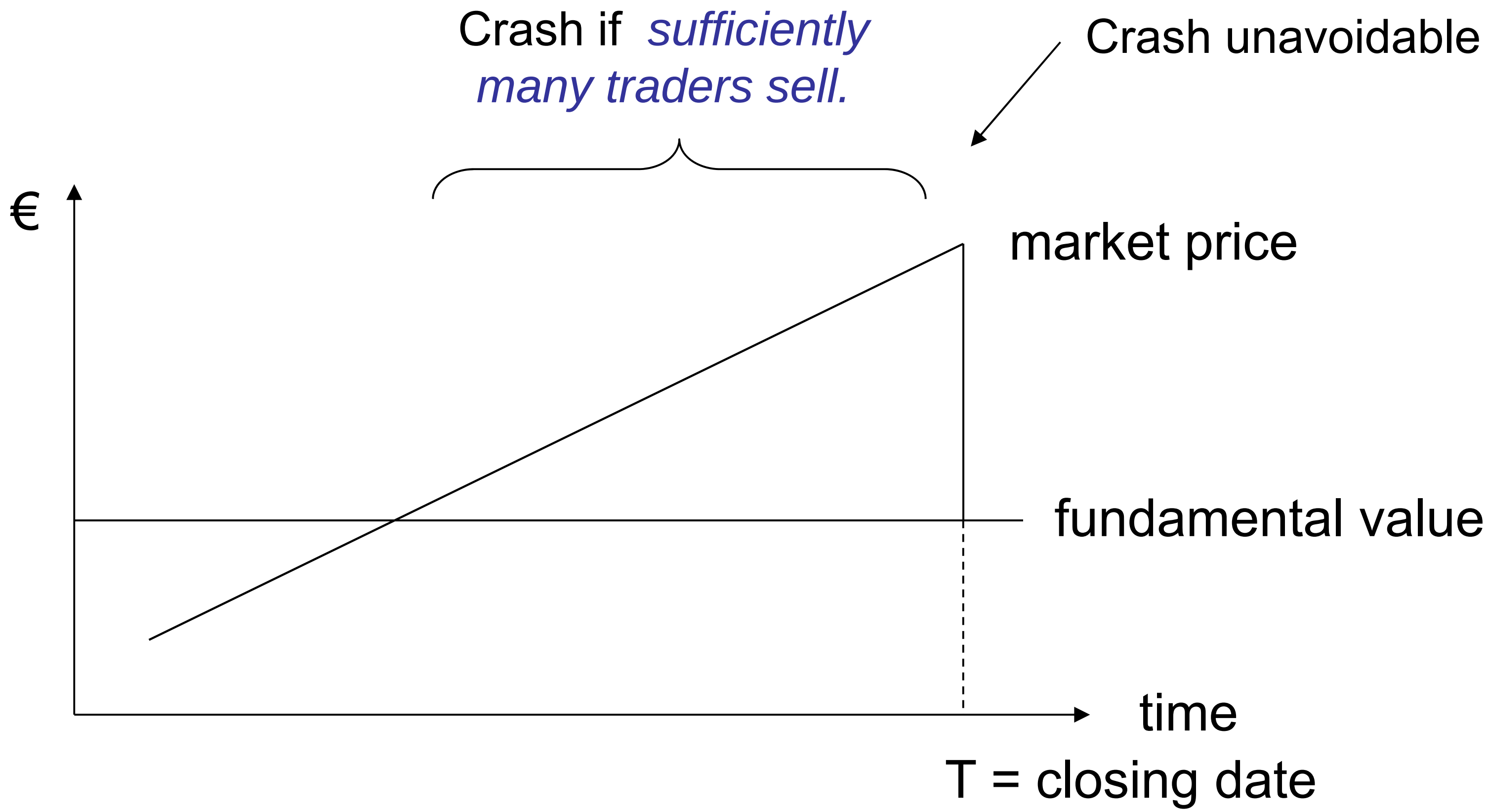
When do bubbles burst?

Abreu & Brunnermeier (Ecmta. 2003), Brunnermeier & Morgan (2005), Cheung & Friedman (2006)



Bubbles and Crashes

Model

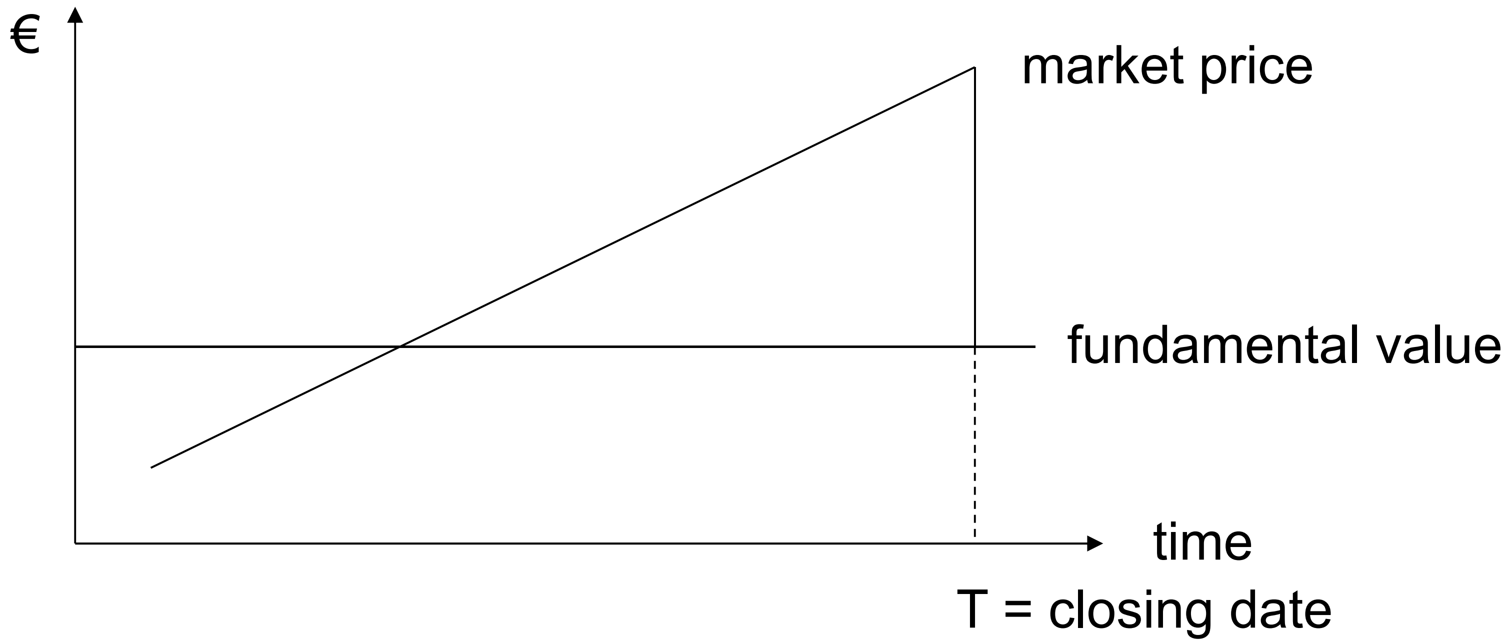


Bubbles and Crashes

When do bubbles burst?

With perfect information, bubbles crash soon after market price exceeds fundamental value.

With rising uncertainty about fundamental value and closing date, bubbles tend to persist longer.



3. Herd Behavior

Decisions reveal information

=> Herding may be rational, provided that observed decisions were based on information

Experiments on rational herding

Anderson & Holt (AER 1997) confirm occurrence of rational herding.

Kübler & Weizsäcker (RES 2004): Subjects may decide, whether to buy private information or follow predecessors.

Result: Subjects have more trust in their own private information than in information revealed by predecessors' acts.

→ ***Limited levels of reasoning***

Bounded rationality reduces likelihood of herding and is, thereby, stabilizing.

4. Bank Runs

Balance sheet:

Aktiva	Passiva
Long-term credits	**deposits**
	equity

Maturity transformation

Leverage: share of equity in banks about 10%

4. Bank Runs

Balance sheet:

Aktiva	Passiva
Long-term credits	**deposits**
	equity

If all depositors withdraw at the same time (**bank run**), then the bank is illiquid.

If *sufficiently many* depositors roll over (don‘t run), the bank can survive.

4. Bank Runs

Iliquidity of banks: depositors withdraw, because they are afraid that the bank will become illiquid. Withdrawel of funds leads to the bank‘s illiquidity (self-fulfilling prophecy).

Bild: Reuters

4. Bank Runs

Schotter and Yorulmazer (JFI 2008):

Subjects play depositors of a bank and have 4 points in time where they can withdraw.

Interest rate => Incentive to leave deposits in the bank

Uncertain earnings of bank => Bank may become insolvent.

Withdrawel of deposits => Bank may become illiquid.

Treatments: different earning distribution and information of depositors.

Main results:

1. If some depositors have insider information about the bank‘s return, bank runs become less likely.

2. A higher mean of the bank’s earnings affects bank runs only if predecessors are observed.

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Inter-bank market

Banks decide whether or not to lend each other liquidity:

Inter-bank market

- If *sufficiently many* banks lend each other, the banking system is stable.
  => all fundamentally solvent banks can survive.

- If banks withdraw liquidity from the inter-bank market, because they fear that other banks collapse, then some banks become illiquid and the system may collapse.

  => systemic banking crisis

  => 1. Collapse of solvent, but illiquid banks.

  2. Contagion to previously liquid banks.

Currency Crises

Traders on FX market decide, whether to speculate on devaluation or not.

Speculative attack:

- If *sufficiently many* traders sell domestic currency, central bank reserves are too small to sustain the exchange rate => Devaluation

  => **Currency crisis**, speculating traders realize profit.

- If only few traders attack, the exchange rate remains fixed.

  => Attacking traders loose on the interest rate differential.

Public Debt

Borrowers on financial markets and rating agencies decide about the soundness of a public debtor.

- If *ratings deteriorate*, the interest rate rises and the country is not able to service its debt

  => **country default**. Those who warned and withdrew, gain reputation and avoid losses on their assets.

- If *ratings are not altered*, the interest rate remains low and the country can service its debt.

  => Those who lend to the country make higher profits.

5. Refinancing Debt:
coordination game with strategic complementarities

You can decide between 2 alternatives:

A   you get 9 Euro

B   you get 15 Euro, if at least 2/3 of all participants decide for B
    0 Euro otherwise

Refinancing a bank

A   Withdraw deposits and loose interest payments

B   Refinance bank at the risk that others withdraw

Coordination Game

You can decide between 2 alternatives:

A you get 9 Euro

B you get 15 Euro, if at least 2/3 of all participants decide for B
0 Euro otherwise

Speculative attack

A safe investment

B speculating against a currency at the risk that too few traders speculate and currency will not be devalued

Coordination Game

You can decide between 2 alternatives:

A	you get 9 Euro

B	you get 15 Euro, if at least 2/3 of all participants decide for B
0 Euro otherwise

Coordination game with 2 equilibria:

A: If agents expect that others choose A, then they decide for A.
=> equilibrium

B: If agents expect others to choose B, then they decide for B.
=> equilibrium

Coordination Game

You can decide between 2 alternatives:

A you get 9 Euro

B you get 15 Euro, if at least 2/3 of all participants decide for B
0 Euro otherwise

Strategic Uncertainty

Optimal decision depends on expectations about decisions of others.
Asuming rationality is not sufficient, to determine a unique outcome.

Multiple Equilibria

Questions:

Predicting behavior?

comparative statics, effects of instruments / regulation?

Effects of information / transparency?

Effects of irrelevant information (sunspots)?
Possibillity of expectation-driven crises

Dynamics for sequential decisions?

Recommendation for individual behavior?

When should the lender of last resort bail out banks,
when should the government guarantee deposits?

optimal regulation?

5.1. Predicting Behaviour and Comparative Statics: The Theory of Global Games

Carlsson and van Damme (1993), Morris and Shin (2003)

Embed the coordination game in a stochastic frame:

state of the world: random variable => payoffs

agents get private signals about state => private beliefs

Players behave as if payoffs are uncertain and as if all players have **private informationen** about payoffs.

=> Payoffs are no longer „common knowledge“

=> Rational player has probabilistic beliefs about beliefs of other players.

Given some technical requirements

=> **Unique equilibrium** with a threshold, s.t. players choose B, if their private signals are on one side of the threshold, while others choose A.

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Experimental Results

Heinemann, Nagel & Ockenfels (REStud 2009)

Experiment (groups of 4, 7 or 10 subjects)

A payoff: X Euro

B payoff: 15 Euro, if *at least a fraction k* of the other group members decide for B,
0 Euro otherwise

X varies from 1,50 to 15 Euro (in steps of 1,50)

k = 1/3, 2/3 or 1

Each subject is in one group playing 30 combinations of X and k.

=> Data for 90 different coordination games

Example: group size N = 7

Situation number	Payoff for A	Your decision A B	Payoff for B
11	1.50	○ ○	in situations 11 – 20: 0 Euro, if less then **K = 5** members of your group choose B. 15 Euro, if at least **K = 5** members of your group (incl. yourself) choose B.
12	3.00	○ ○	
13	4.50	○ ○	
14	6.00	○ ○	
15	7.50	○ ○	
16	9.00	○ ○	
			OK

A payoff of 9 Euro

B payoff of 15 Euro, if at least 2/3 of the other group members decide for B,

0 Euro otherwise

Example: group size N = 7

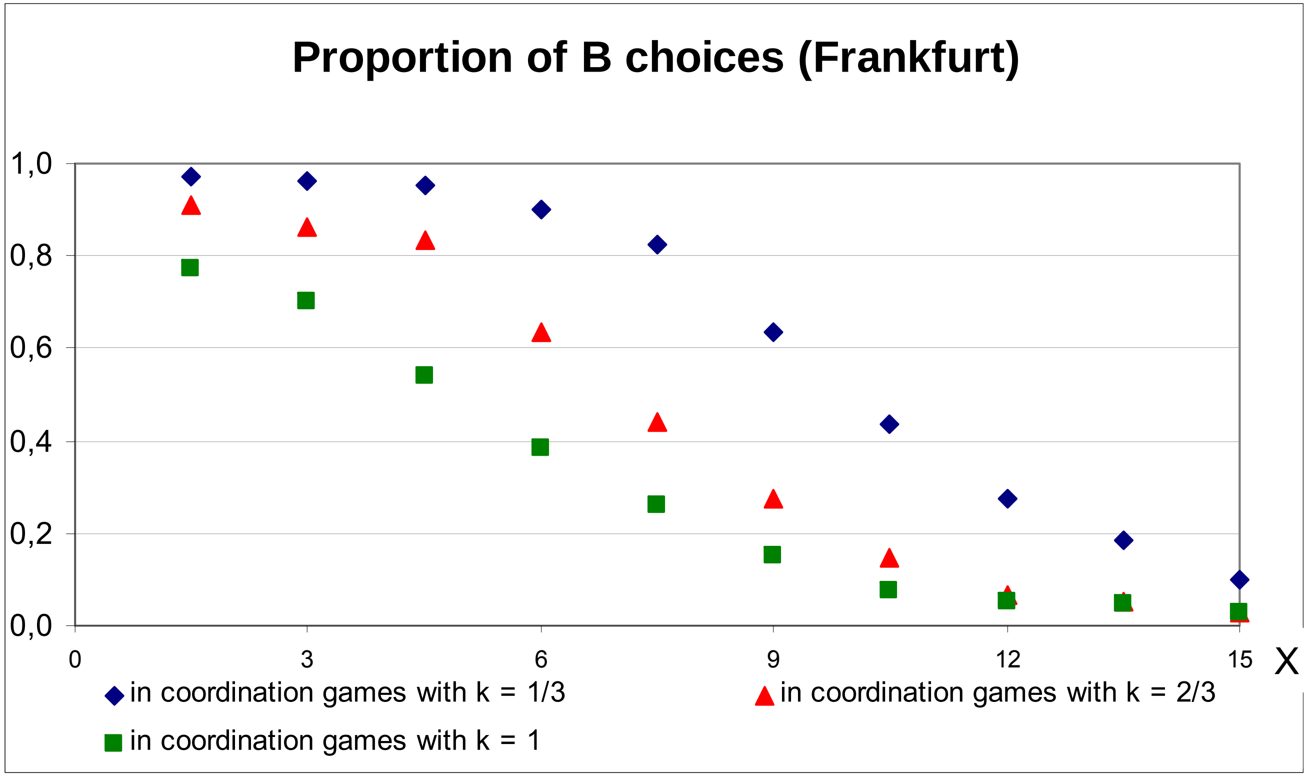
Situation number	Payoff for A	Your decision A	Your decision B	Payoff for B
11	1.50	○	⊗	in situations 11 – 20: 0 Euro, if less then **K = 5** members of your group choose B. 15 Euro, if at least **K = 5** members of your group (incl. yourself) choose B.
12	3.00	○	⊗	
13	4.50	○	⊗	
14	6.00	○	⊗	
15	7.50	○	⊗	
16	9.00	○	⊗	
17	10.50	⊗	○	
18	12.00	⊗	○	
19	13.50	⊗	○	
20	15.00	⊗	○	
				OK

Experimental Design

- Subjects receive 4 tables with 10 situations each
  (3 x coordination games with different k, 1 x lotteries)
- We pay for <u>one</u> randomly selected situation
  + 5 Euro "show-up fee"
- 300 subjects at 4 different places

- Duration 40 – 90 minutes
- Average payoff: 16,88 Euro

Comparative Statics



The larger the safe payoff X and the higher k (the fraction of others needed for success of B), the fewer subjects choose B.

Group size N has no significant impact.

Probabilities for success of B

prob(success) = 1 – Bin(K-1,N,p)

N	K	k	1.50	3	4.50	6	7.50	9	10.50	12	13.50	15
4	2	1/3	1.00	1.00	1.00	0.99	0.98	0.86	0.59	0.29	0.16	0.06
7	3	1/3	1.00	1.00	1.00	1.00	0.98	0.92	0.64	0.27	0.10	0.10
10	4	1/3	1.00	1.00	1.00	1.00	1.00	0.94	0.73	0.49	0.22	0.12
4	3	2/3	0.92	0.92	0.88	0.66	0.27	0.06	0.01	0.01	0.00	0.00
7	5	2/3	0.90	0.68	0.73	0.36	0.13	0.04	0.00	0.00	0.00	0.00
10	7	2/3	0.95	0.95	0.88	0.22	0.04	0.00	0.00	0.00	0.00	0.00
4	4	1	0.37	0.27	0.14	0.04	0.01	0.00	0.00	0.00	0.00	0.00
7	7	1	0.09	0.04	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	10	1	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Frankfurt data (all participants).

In 44 out of 90 situations (49%) success or failure can be predicted with an error rate of less than 5% across subjects pools (but in sample).

58 out of 90 (64%) with data from one subject pool (Frankfurt)

Global Game

Assume that subjects are risk averse, but know only their own risk aversion. With probability ε, a player makes a mistake (C. Hellwig 2002).

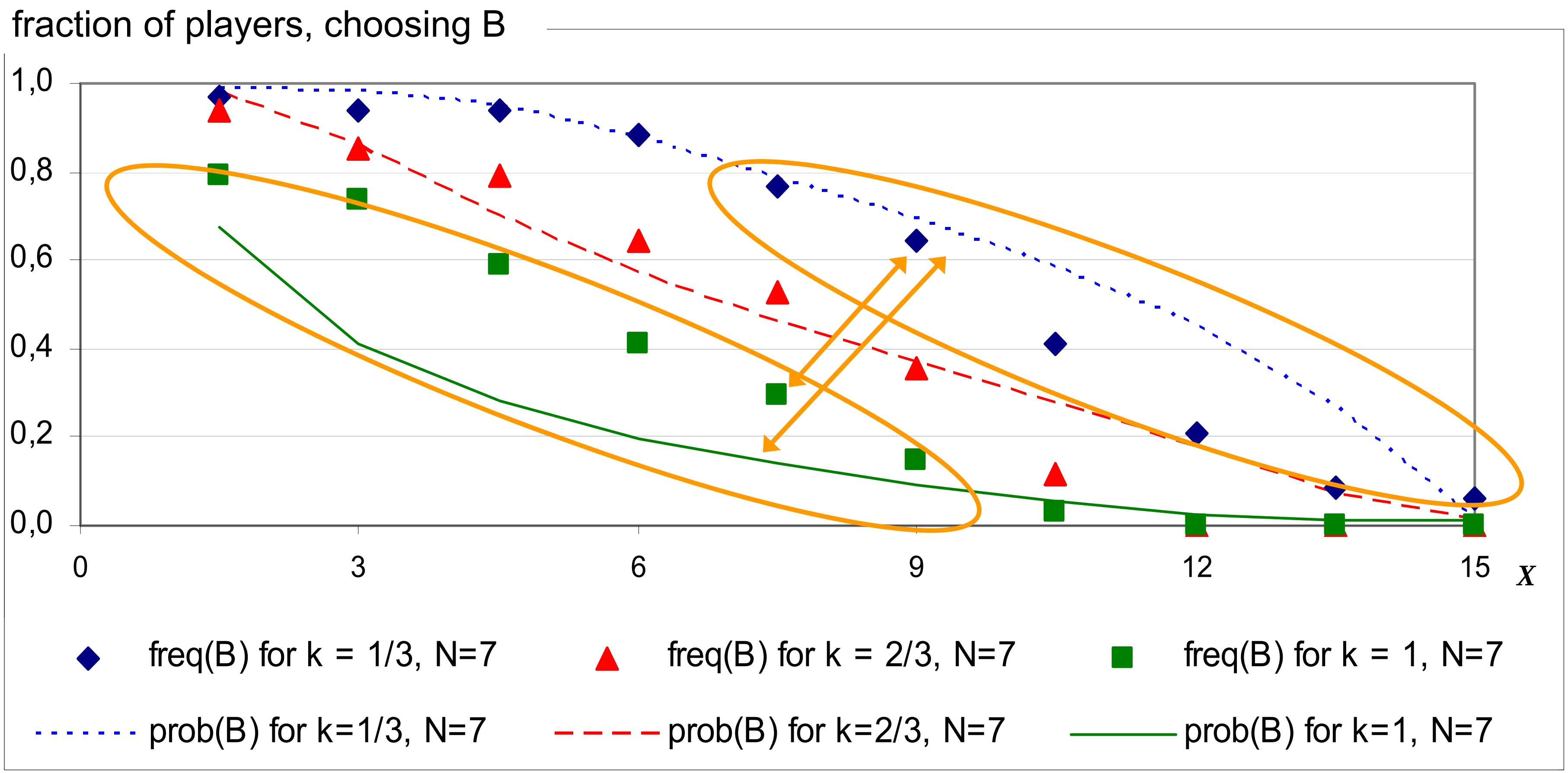
Distribution assumption: ARA ~ normal(mean α, variance σ^2).

In equilibrium there is a threshold for each game (N,K,X), $\alpha^*(N,K,X,\sigma,\varepsilon)$ s.t. players with higher risk aversion choose A, while players with lower risk aversion choose B.

$$\int_{-\infty}^{\infty}\left[\frac{1-\exp(-a15)}{a}\cdot\left(1-Bin\left(K-2,N-1,p(N,K,X,a,\sigma,\varepsilon)\right)\right)-\frac{1-\exp(-aX)}{a}\right]\phi\left(\frac{a-\alpha^*}{\sigma}\right)da=0$$

$$p(N,K,X,\alpha,\sigma,\varepsilon)=(1-\varepsilon)\,\Phi\left(\frac{\alpha^*-\alpha}{\sigma}\right)+\varepsilon\left(1-\Phi\left(\frac{\alpha^*-\alpha}{\sigma}\right)\right)$$

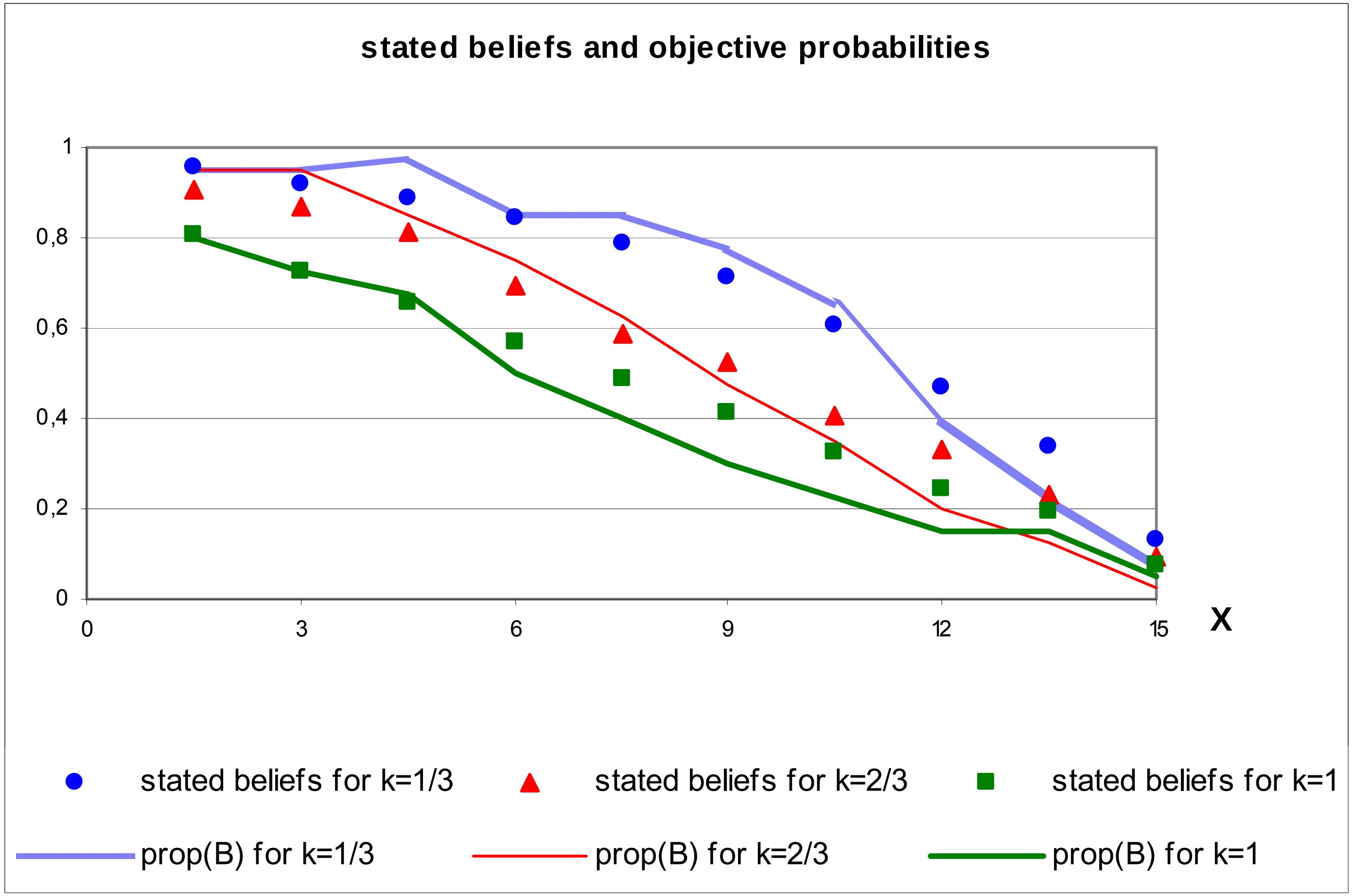
Observations and estimated model



Theory of global games can be used for predicting the fraction of B-choices.

Individual Expectations

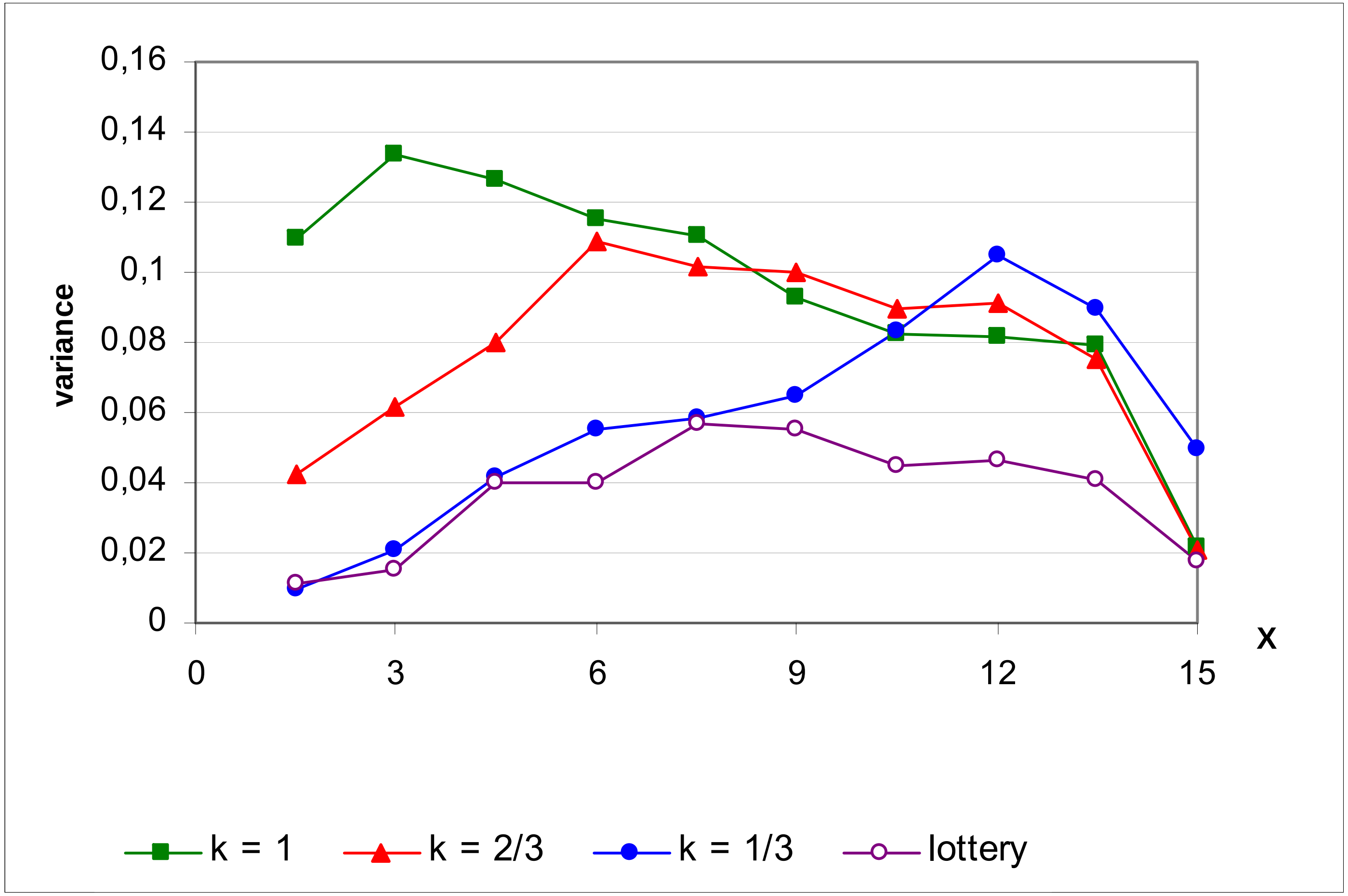
On average, expectations about others‘ decisions are correct.



Data from two sessions with belief elicitation

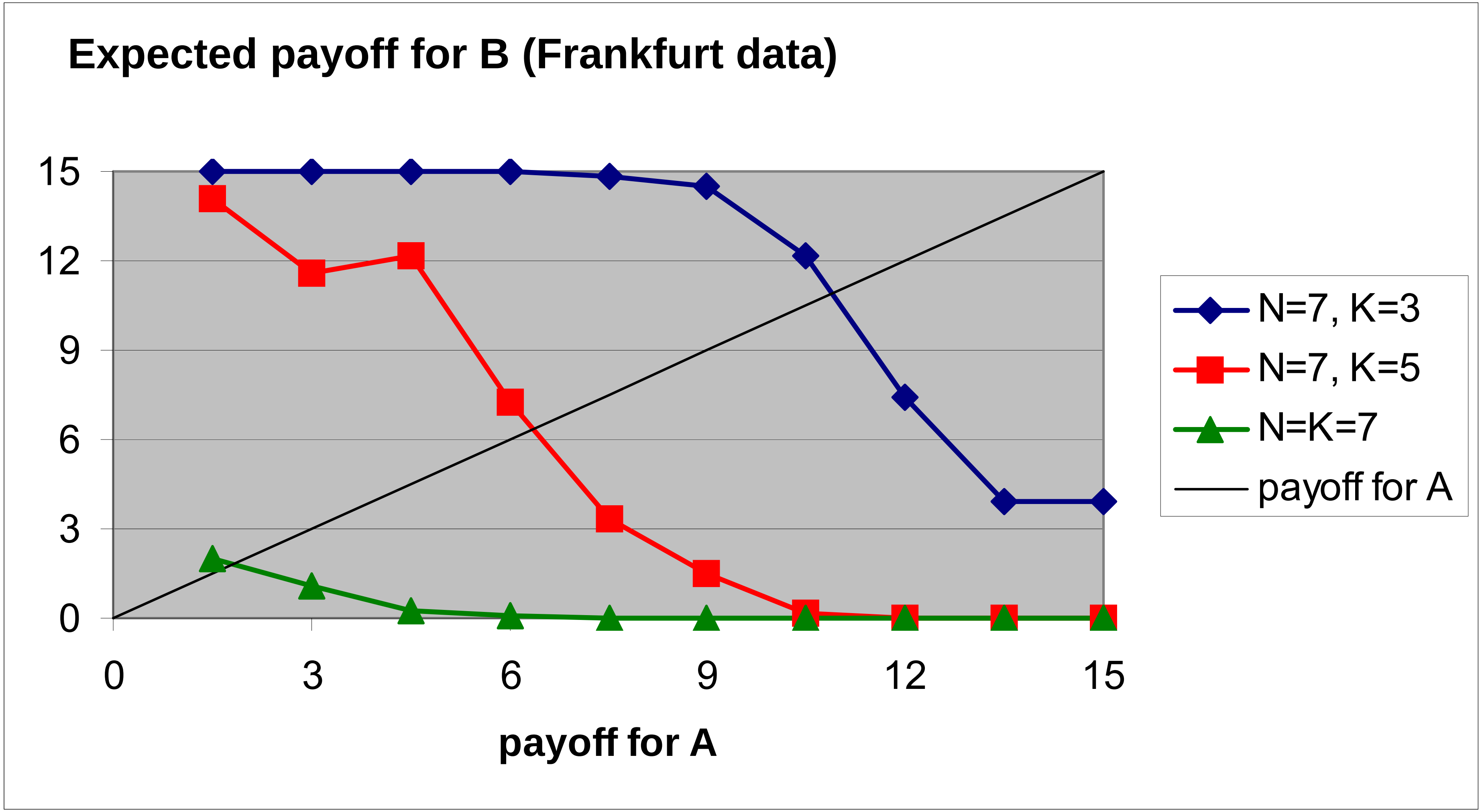
Individual Expectations

In situations, in which we have troubles predicting behaviour, the variance of expectations is particularly large.



5.2 Individual Recommendation:

Choose B, if expected payoff exceeds payoff for A



Individual recommendation

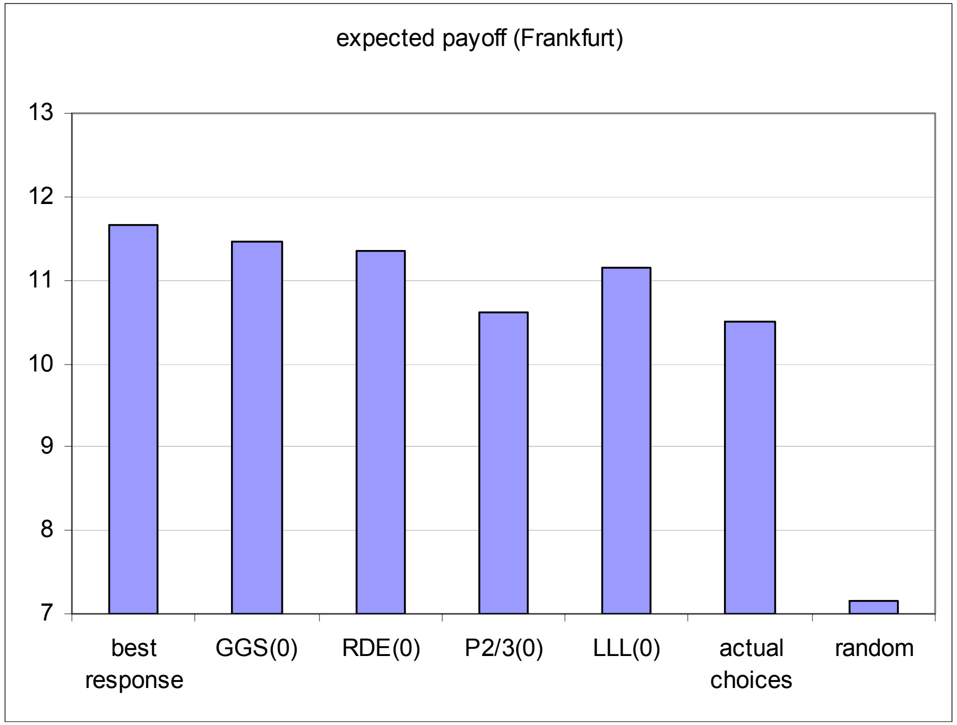
Goal: Define a simple Strategy, with which a player can achieve a high payoff.

Global Game Selection: Equilibrium of a global game with diminishing variance of private signals

$\Rightarrow$ Choose B, if

$$X < 15\left(1 - \frac{K-1}{N}\right)$$

Example N=7, K=5 => X* = 6,4



5.3 Managing Information Flow

Heinemann, Nagel & Ockenfels (Ecta. 2004)

Experiment (Groups of 15 subjects)

A payoff: 20

B payoff: Y, if *sufficiently many* subjects choose B,

0 otherwise

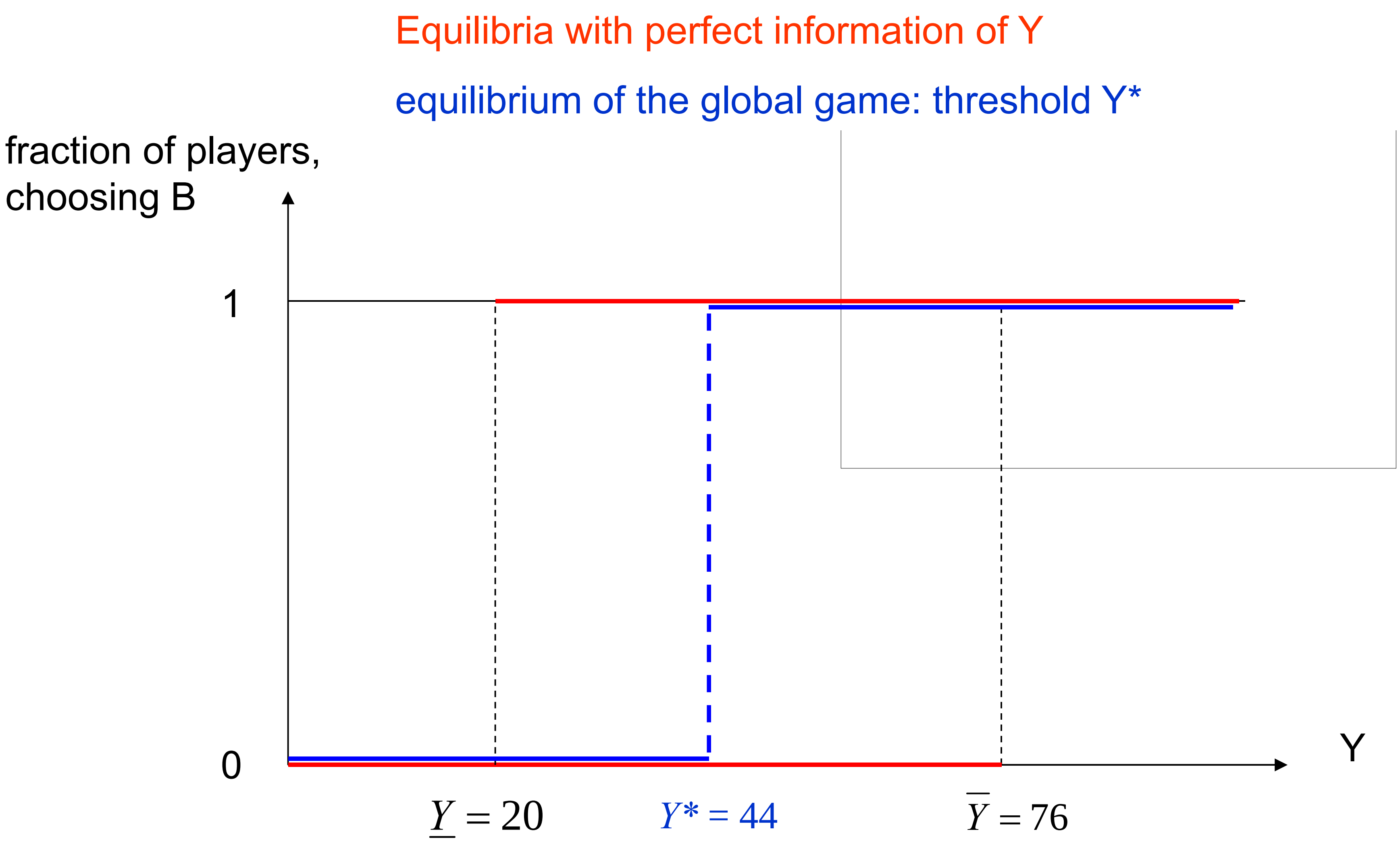
Y = random number with uniform distribution in [10, 90]

Compare 2 information treatments:

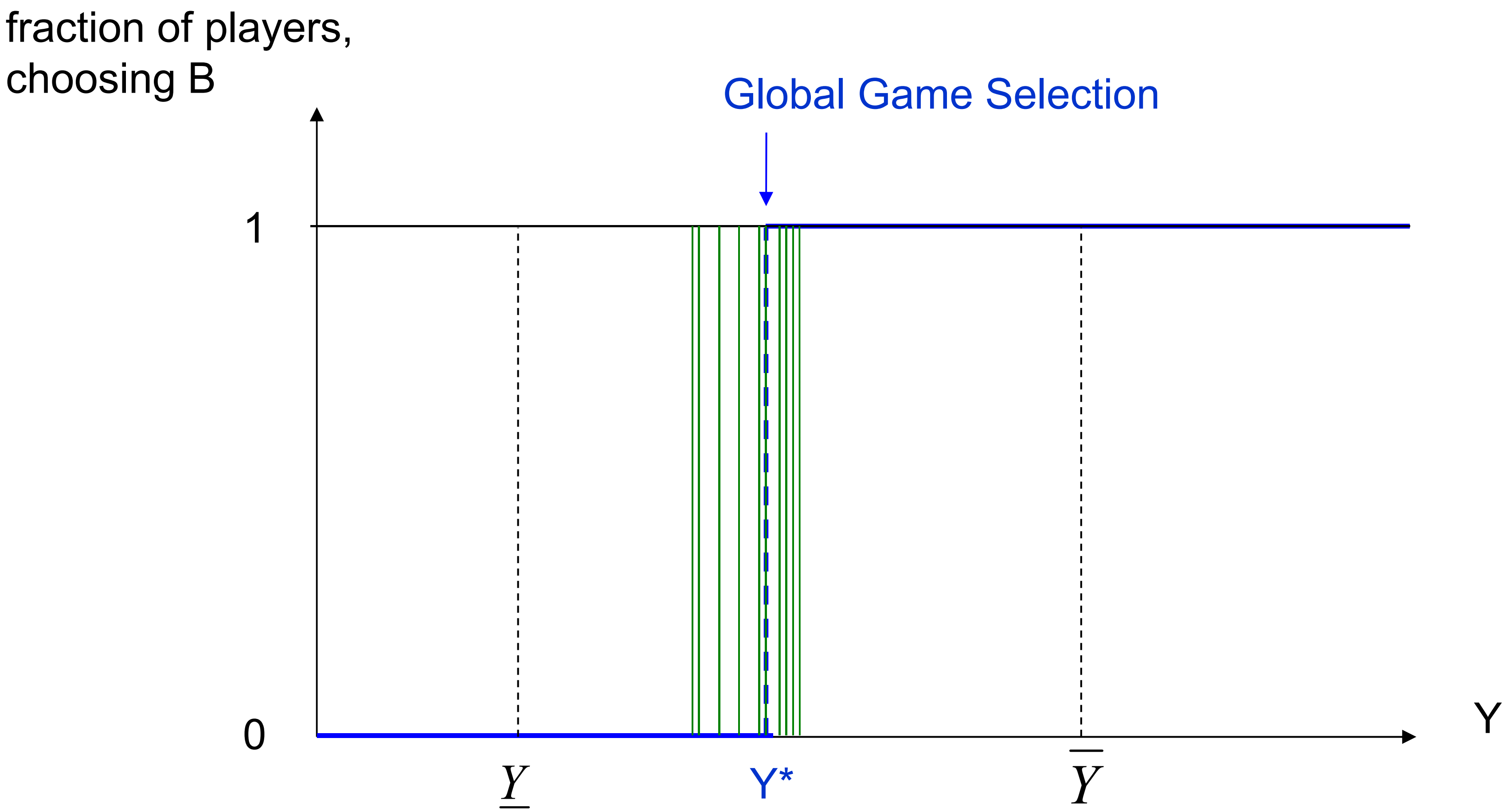
- Y is common (public) information
- subjects receive private signals in [Y-10, Y+10]

repeated game

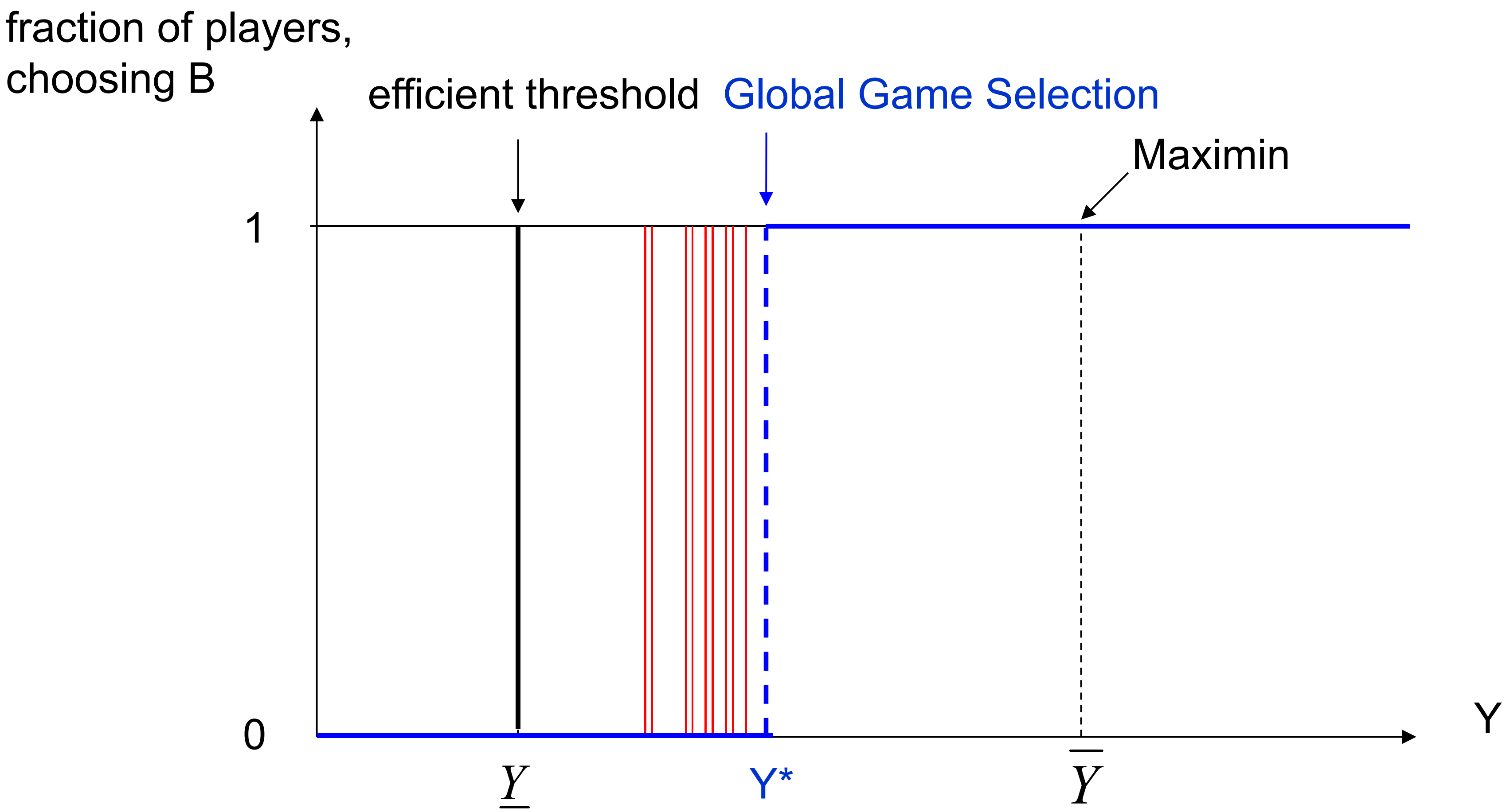
Experiment: Heinemann, Nagel & Ockenfels (2004)



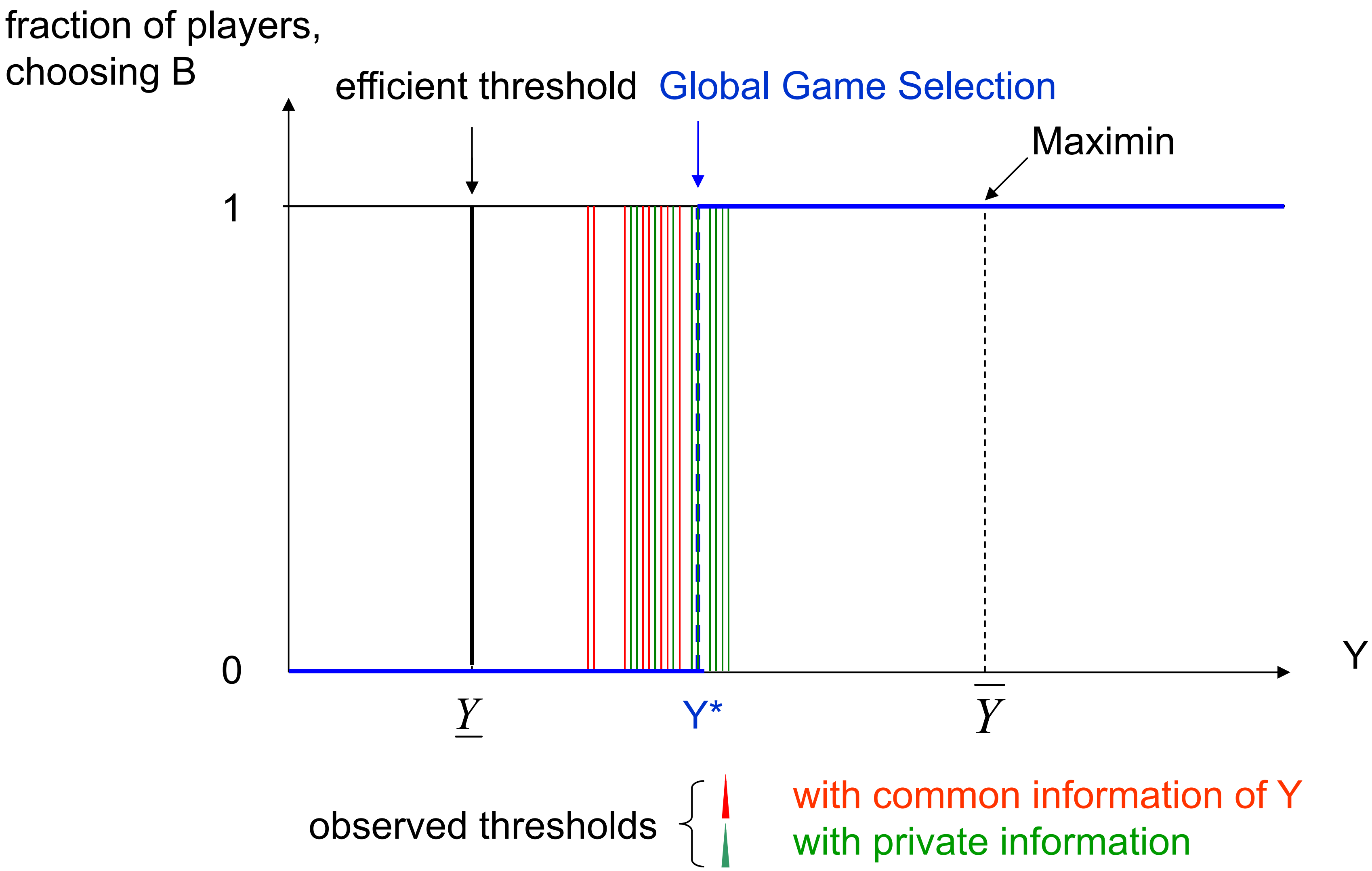
Observed thresholds with private information



Observed thresholds with common information



Equilibria and observations in the experiment



Experiment: Heinemann, Nagel & Ockenfels (2004)

Theory:

Common information => multiple equilibria => large dispersion of thresholds, if different groups coordinate on different equilibria.

=> outcome is unpredictable

Results from the experiment:

1. **Predictability is eqally good for common and private information**
2. Common information yields to more efficient strategies
3. Systematic deviation of behavior from *Global-Game Selection* towards more efficient strategies.

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5.4 Cheap Talk versus efficient markets

Experiment, Qu (WP 2011):

Game with private information as in HNO (2004) as „baseline“

Other treatments:

Market: First, subjects trade contingent claim. Price aggregates private information. Decisions to „invest“ can be based on that price.

Cheap talk: First, subjects announce their intension whether or not to invest. Decisions to „invest“ can be based on number of announced investments.

Results:

1. **Having a market raises ability to coordinate, but subjects often coordinate on the inefficient equilibrium.**
2. **Cheap talk raises coordination and efficiency, although it is a weakly dominating strategy to always announce an investment.**

Open question: why is cheap talk more efficient than the market?

5.5 Welfare effects of public information

Game with strategic complementarities and unique equilibrium

Theory: agents should put a larger weight on public than on private signals of same precision. In equilibrium public signals may reduce welfare (Morris/Shin, AER 2002)

Experiment (Cornand and Heinemann, 2011):
observe higher weight on public signals, but lower than in equilibrium. Data are consistent with level-2 reasoning.

Theory: For level-2 reasoning, public signals cannot reduce welfare!

Non-Bayesian higher-order beliefs

Subjects violate Bayes‘ rule when forming higher-order beliefs:

unknown state $Z \sim U[50, 450]$.

Each subject receives a common signal Y and a private signal X^i.

$Y, X^1, X^2 \sim$ i.i.d. $U[Z-20, Z+20]$

Each subject is asked for a guess of Z.

Bayesian answer: $E^i (Z|Y,X^i) = (X^i+Y)/2$.

Each subject is asked to guess another subject‘s guess of Z.

Bayesian: $E^j (E^i (Z|Y,X^i)| Y,X^j) = (E^j(X^i)+Y)/2 = (E^j(Z)+Y)/2 = 0.75\ Y + 0.25\ X^j$.

Most subjects put weights around 0.3 – 0.4 on their private signal when estimating their partner‘s guess of Z.

5.6 Sequential Decisions

Duffy & Ochs (WP 2011): dynamic version of HNO (2004)

Subjects have 10 periods to enter the B-mode.

Decision for B is irreversible. Subjects who have not decided for B in t=10, stay with A.

Y is common information in the first period already.

Treatment with waiting cost: subjects receive lower payoffs from B if they enter in later periods.

Subjects can observe, how many other subjects decided for B in previous periods.

Results:

If there are no costs for waiting, thresholds to enter are about the same as in the one-shot game

If costs of waiting are introduced, subjects converge to more efficient strategies, i.e. they enter more often.

Sequential Decisions

Costain, Heinemann & Ockenfels (2007)

N = 8 subjects decide between A and B sequentially <u>in a given order</u>.

A payoff 30

B payoff Y, if sufficiently many subjects choose B,

0 otherwise

Y is random, uniform distribution in [15, 85]

Private information: Each sibjects receives a signal X_i from [Y-15, Y+15]

Subjects can observe predecessors with some probability *q*.

Sequential Decisions

- Full rationality, high observability of predecessors (q large)

  => Success of B (Refinancing bank or attacking currency) depends on the signals of those who decide first. Rational herding!

- Bounded rationality: players attack with some probability

$$\frac{\exp(\lambda^{-1}u(1))}{\exp(\lambda^{-1}u(0)) + \exp(\lambda^{-1}u(1))}$$

where $u(0)$ = payoff for A (no attack)

$u(1)$ = expected payoff for B (attack)

Rationality parameter λ ($\lambda \to \infty$ => random decisions)

- For both models: distribution of signals induces a distribution of the fraction of attacking players, conditional on Y.

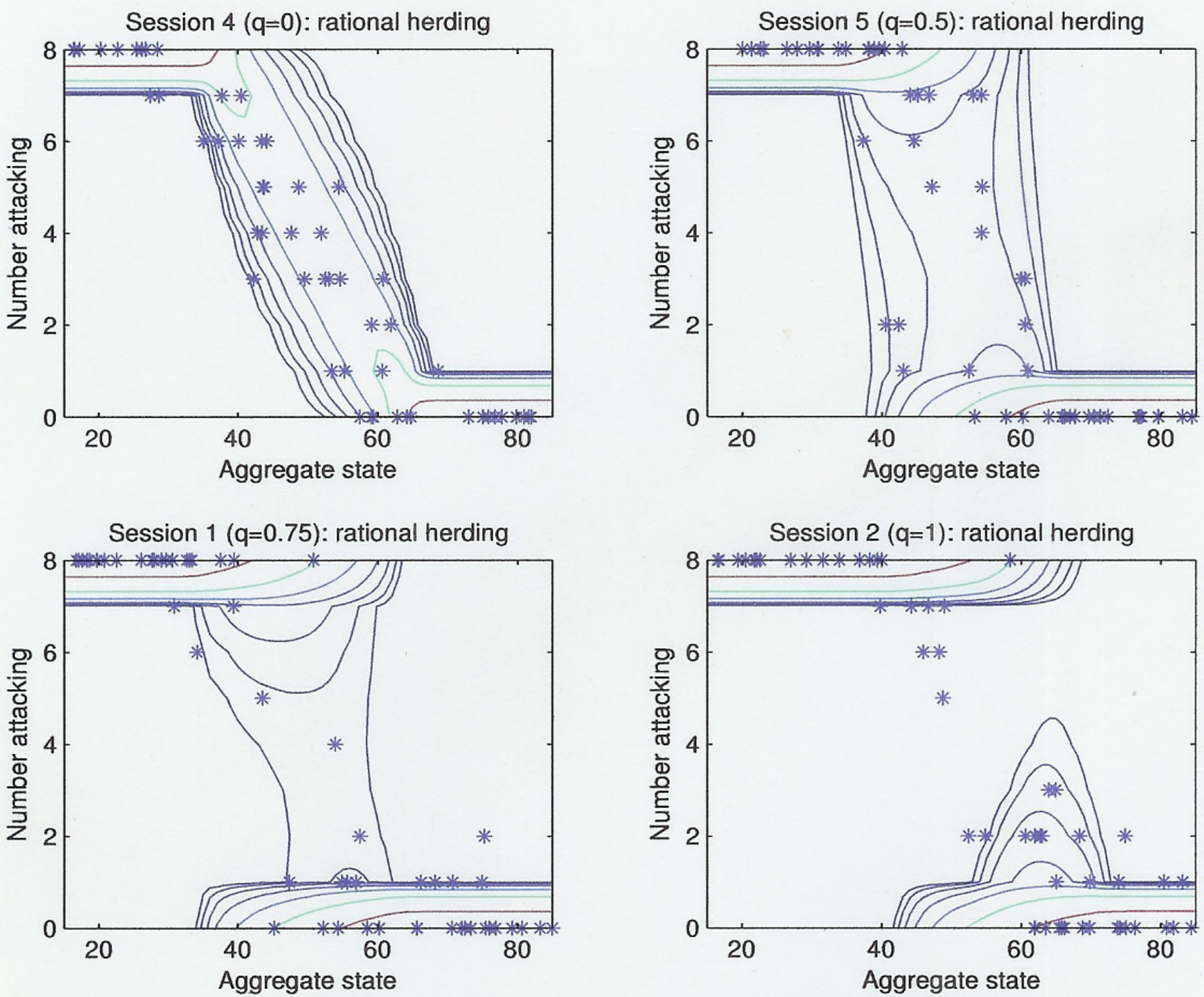

Figure 3: Contours of outcome probabilities $\hat{p}_I$ in rational herding equilibrium, with experimental observations.

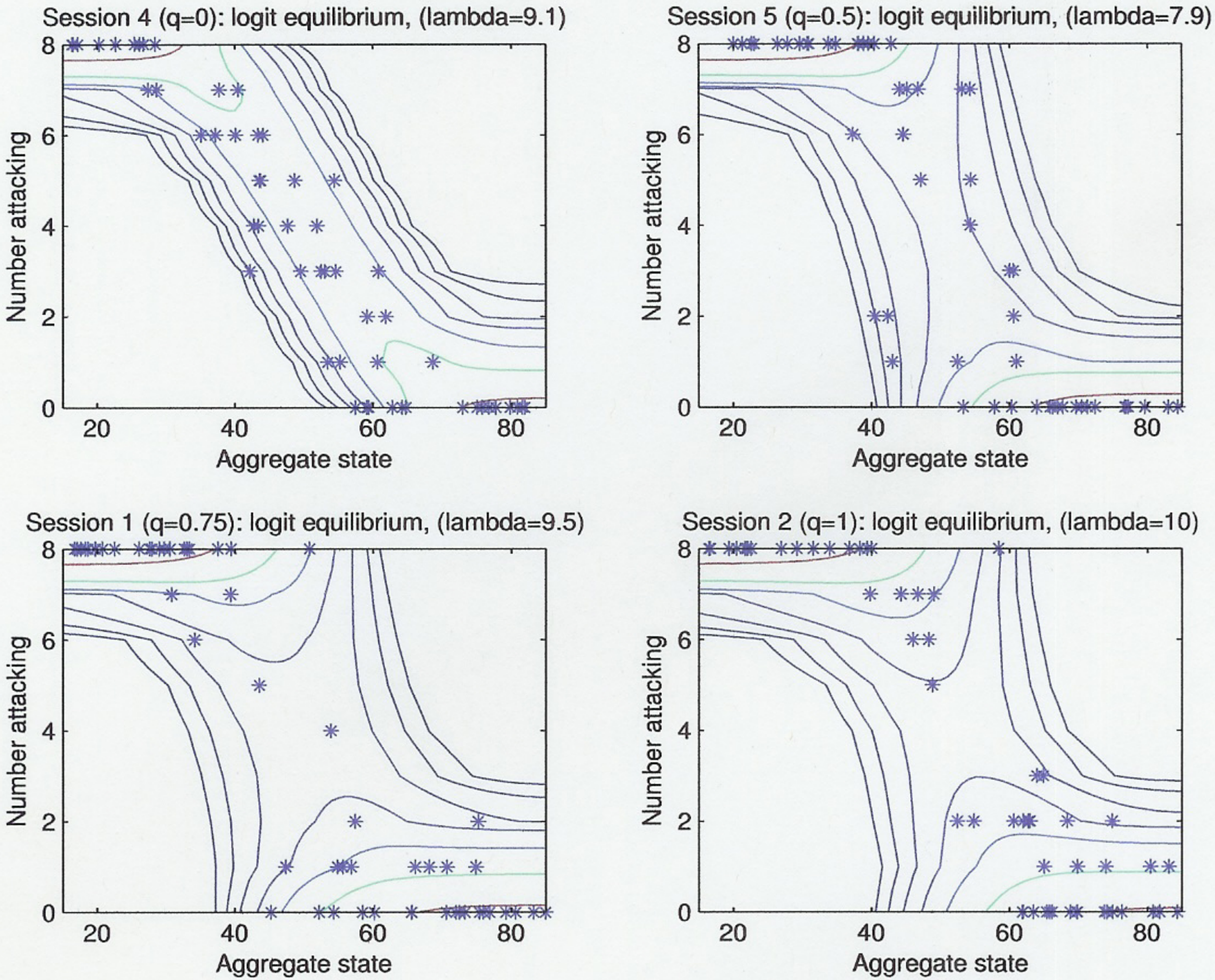

Figure 6: Contours of outcome probabilities $\hat{p}_I$ in estimated logit equilibrium, with experimental observations.

Sequental Decisions

- Higher rationality and better information about predecessors advances herd behavior and makes it more difficult to predict the outcome.

⇒ **If agents are fully rational it is not possible to predict attacks even with private information.**

⇒ **With boundedly rational agents, it is easier to predict the outcome.
Bounded rationality is stabilizing the economy!**

6. The Power of Sunspots

Fehr, Heinemann & Llorente-Saguer (WP 2011)

1. Pure Coordination game (without additional information)

Groups of 6: each subject is randomly matched with another subject.

- Choose a number between 0 and 100 (incl. 0 and 100).
- Your payoff is higher, the closer your choice is to the choice of your partner.
- Your payoff (in Euro Cents) = $100 - \frac{1}{100}\left(\textit{your choice} - \textit{partner's choice}\right)^2$
- I.e.: your payoff is at most 100 Euro Cents. It is reduced by the quadratic deviation of your choice from your partner‘s choice.
- The closer your and your partner‘s choices are, the larger is your payoff.

The game is repeated 80 times!

The Power of Sunspots

1. Pure Coordination game

Any number in [0, 100] is an equilibrium.

„50“ minimizes your risk (Maximin strategy).

Risk dominance: the further a number is from 50, the higher the associated strategic risk.

In experiment:

all groups converge to 50

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The Power of Sunspots

2. Treatment with extrinsic public signal

- The computer randomly selects a number **Y**: „0“ or „100“ with prob. ½.
- You and your partner observe the same number **Y**.
- You and your partner have to choose a number from 0 to 100 simultaneously. Payoff as before.

Each function a(Y) is an equilibrium. **Y** may serve as a focal point.

In experiment:

all groups converge to „action = Y“

=> the experiment reliably produces sunspot equilibria.

The Power of Sunspots

3. Treatment with correlated private signals:

Both players receive private signals „0“ oder „100“. With probability 90% signals are the same, o.w. opposed.

2 groups coordinate on „ $action_i$ = 10 [90], if X_i = 0 [100]“.

Other 4 groups: „action = 50“ independent from signal.

=> Extrinsic signals may affect behavior, even if this no equilibrium.

The Power of Sunspots

4. **Each subject receives a common signal with probability 90%**

   → External effect of sunspot-driven behavior on uninformed players

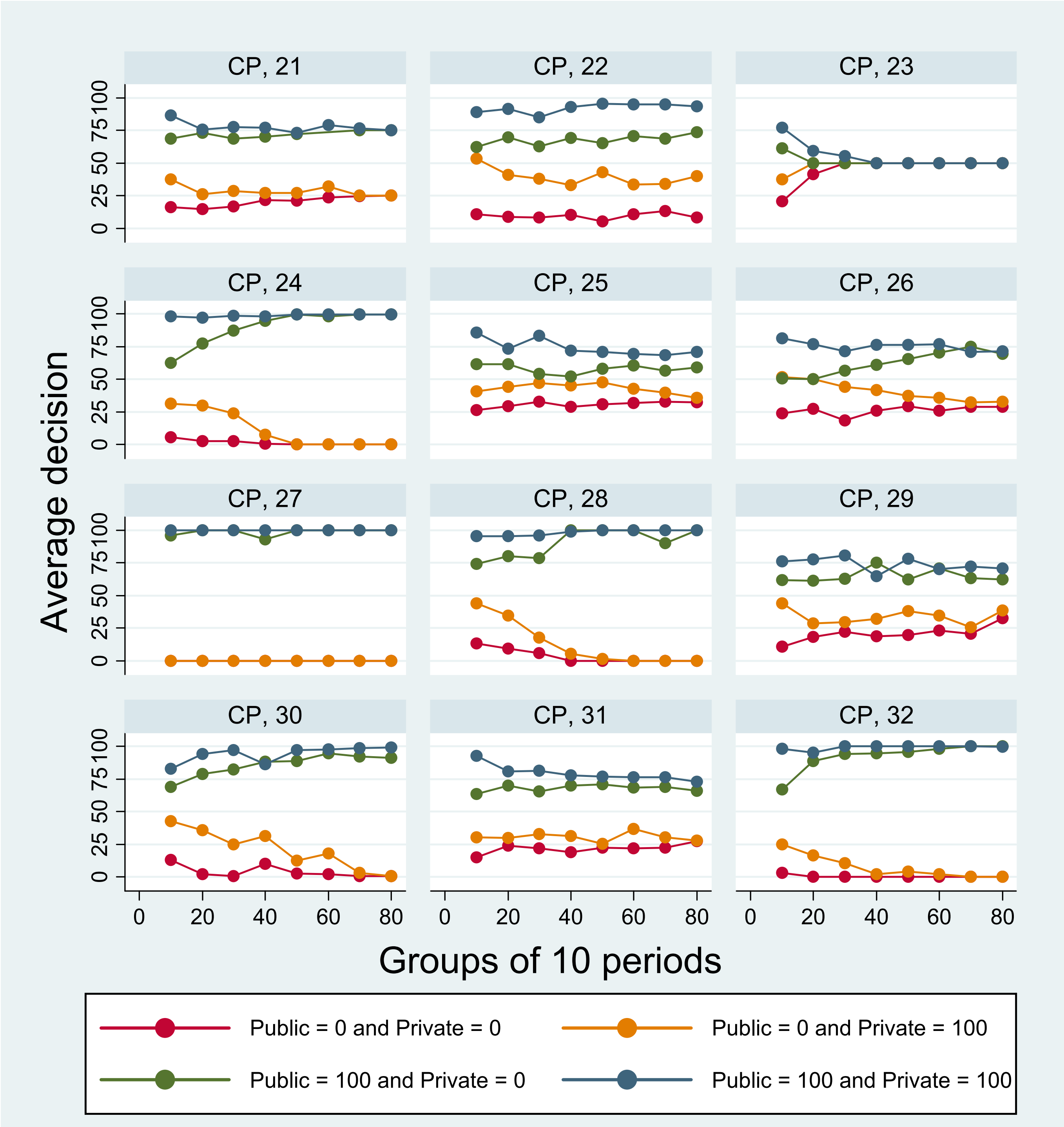
5. **Two public signals X and Y**

   → all 6 groups converge to 3-state sunspot equ. action = 0 [100] if both signals = 0 [100], 50 if X ≠ Y.

6. **One public signal Y and one private signal X_i**

   → significant efficiency losses! some groups do not manage to coordinate in 80 periods!

   → different groups coordinate on different equilibria.



CP, 21
CP, 22
CP, 23
CP, 24
CP, 25
CP, 26
CP, 27
CP, 28
CP, 29
CP, 30
CP, 31
CP, 32
Average decision
0
25
50
75
100
0
20
40
60
80
Groups of 10 periods
Public = 0 and Private = 0
Public = 0 and Private = 100
Public = 100 and Private = 0
Public = 100 and Private = 100

Multiple Equilibria

Questions:

Predicting behavior	√
comparative statics	√
Effects of intrinsic information (public vs. private)	√
Effects of extrinsic information (sunspots)	√
Dynamics for sequential decisions	√
Recommendation for individual behavior	√

Conclusions for understanding financial crises

1. A bubble is unlikely to arise in a market in which traders experienced a bubble before under similar conditions.
2. Bubbles are more likely to arise if fundamental value is uncertain.
3. Herd behavior is mitigated by „limited levels of reasoning".
4. Behavior in coordination games is fairly predictable.
5. Coordination games, in which behavior is hard to predict can be identified by diverse expectations.
6. Comparative statics follow „global-game selection".
7. GGS gives good recommendation for individual behavior.
8. Public information leads to more efficient coordination in refinancing games.
9. Sunspot equilibria are more than a theoretical curiosity.
10. Extrinsic public and private information may affect behavior.
11. Irrelevant informationen may reduce ability to coordinate.