Speculative Attacks and the Theory of Global Games

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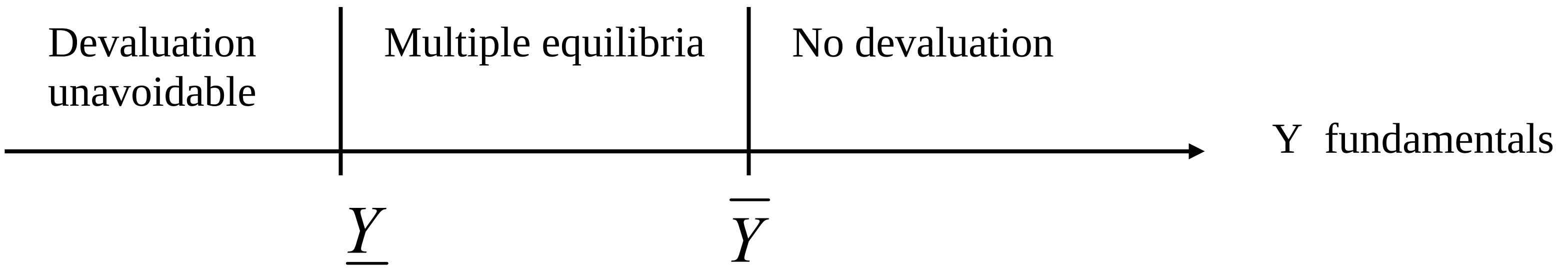
Coordination games with multiple Equilibria

Currency Attack (Obstfeld, 1986, 1996, 1997)

If traders expect devaluation, they sell currency.

Increased supply generates pressure to devaluate.

In critical cases, pressure gets large enough for central bank to devaluate, even if it had kept the current rate without this pressure.

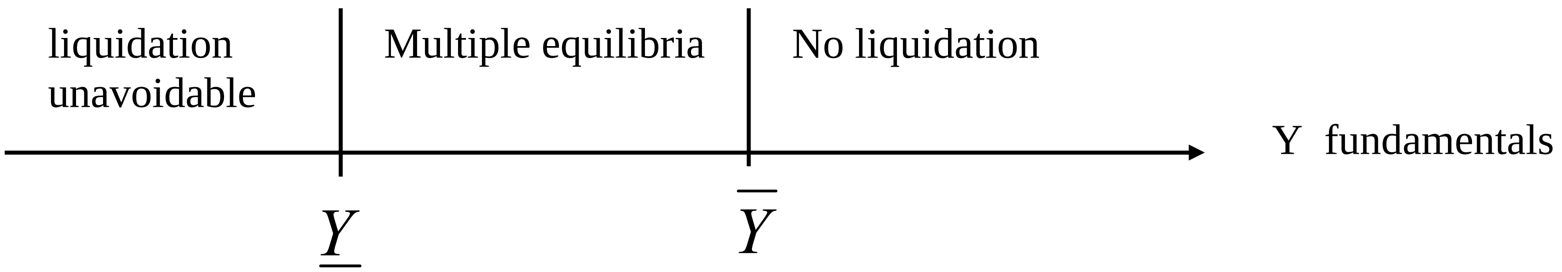


Firm Liquidation

Borrowers expect liquidation and therefore withdraw credit

$\Rightarrow$ Higher costs of capital

$\Rightarrow$ in critical cases: Bankruptcy that could have been avoided without higher costs of capital even if it had kept the current rate without this pressure.



Other coordination games with similar structure:

Bank runs

Competition between intermediaries

Competition between networks

Multiple equilibria

= Self fulfilling beliefs

= Existence of sunspot equilibria

Financial system is prone to sudden shifts in beliefs that may trigger a crisis.
Shifts in beliefs do not need to be related to news on fundamentals.

Inherent instability

Financial Crises are (to some extend) unpredictable

Impossibility to analyse comparative statics
No clear policy recommendations

Other viewpoint:

The model has multiple equilibria, because it lacks an important determinant of decisions

A Speculative-Attack Model

Literature: Morris / Shin (1998), Heinemann (2000)

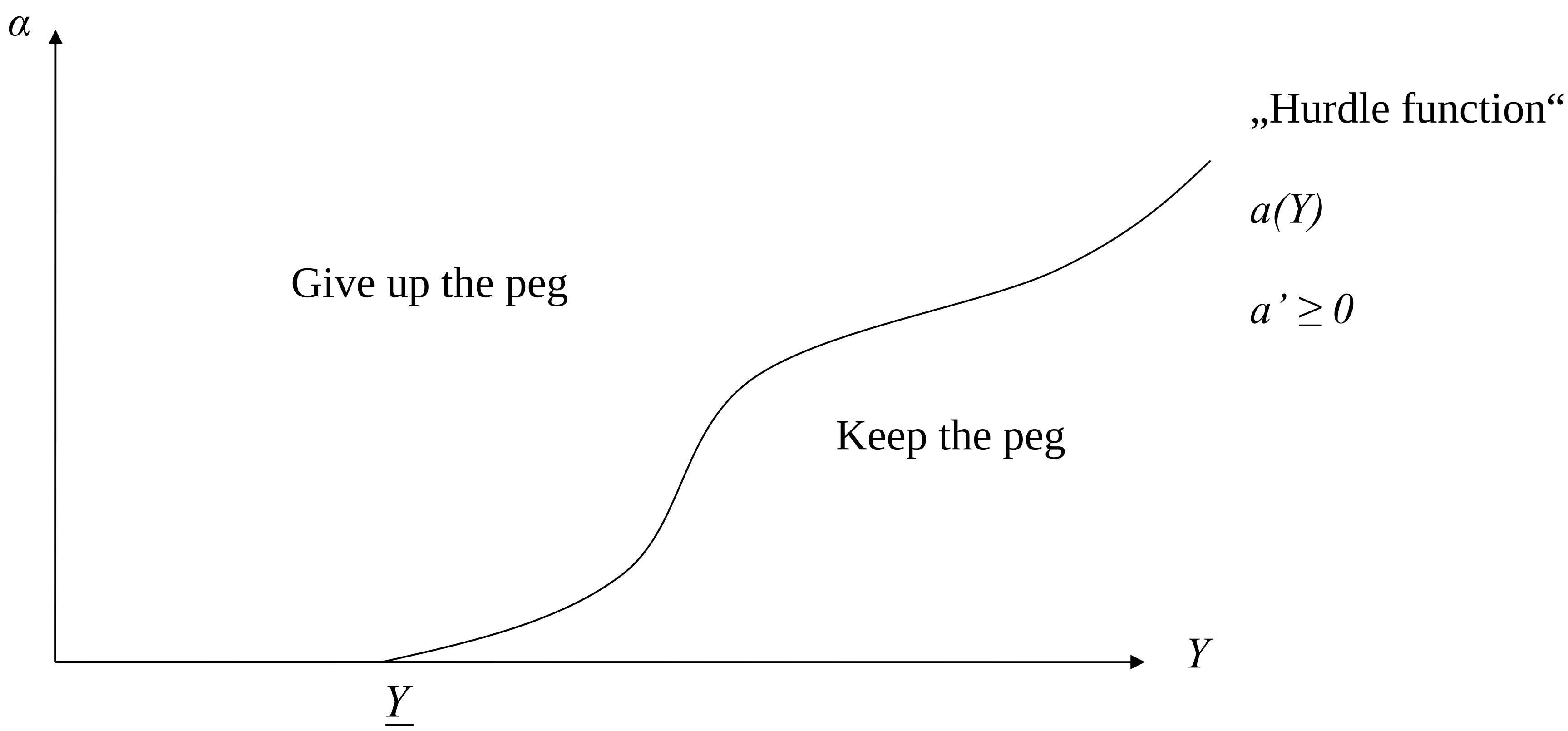
Nature selects	Y	random, uniform in [0,1]
Fixed exchange rate	$e*$	measured in foreign curr. / domestic curr.
Shadow exchange rate	$f(Y)$	$f' > 0$

Higher state Y = better state of the economy

2-stage game:

1. Private agents decide on whether or not to attack the currency. Continuum of agents $i \in [0,1]$
   Attack = sell domestic currency. Each agent can sell one unit.
   Let α be the proportion of agents who sell the currency (measure of speculative pressure).
2. Central bank gives up the currency peg if and only if proportion of attacking agents is larger than a hurdle $a(Y)$.

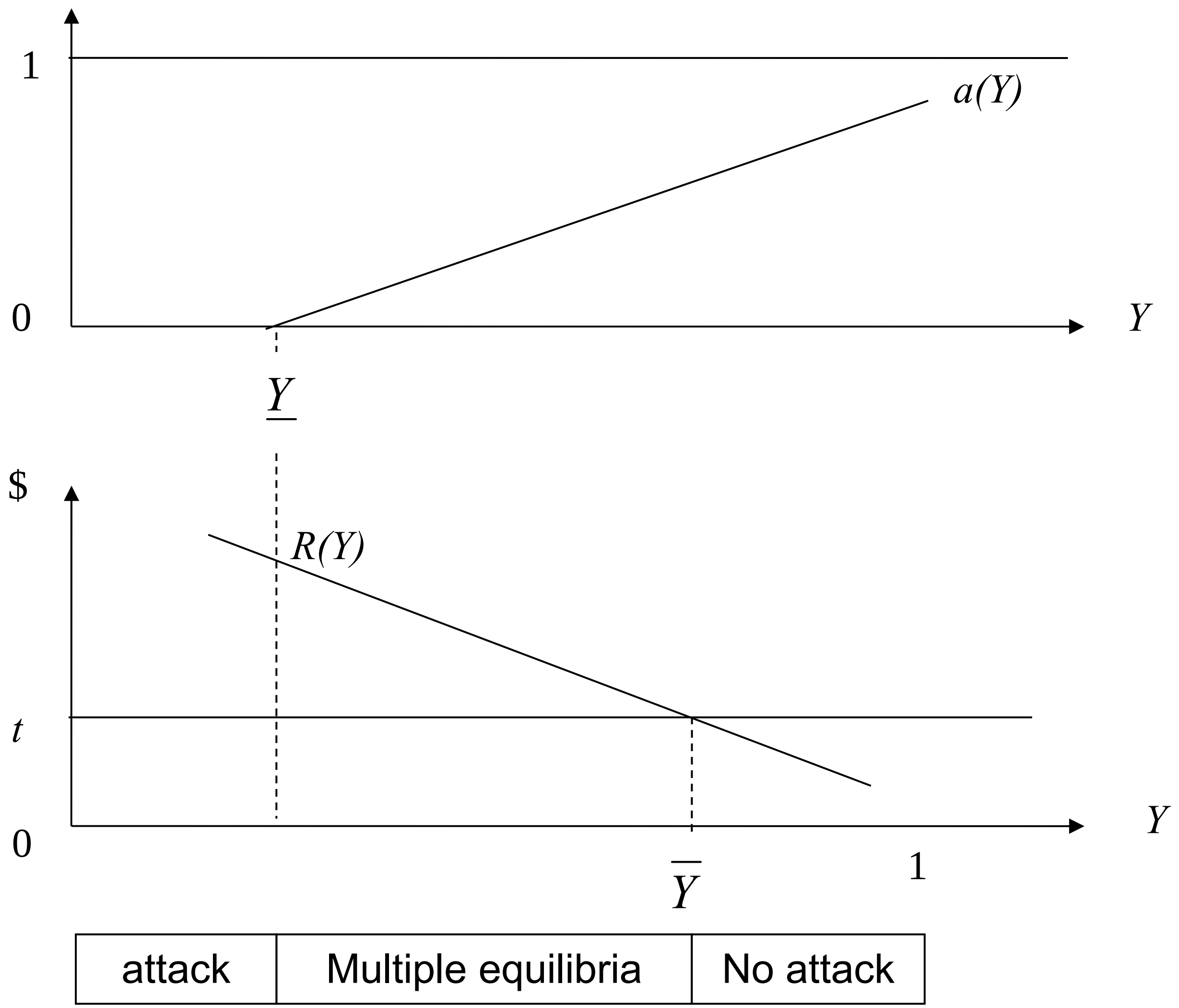
If attack is successful, attacking agents earn $R(Y) - t = e* - f(Y) - t$.
If attack fails, attacking agents lose t.



Assume: 1. there is a state $\underline{Y} > 0$ with $a(\underline{Y}) = 0$ => for $Y < \underline{Y}$ the CB gives up anyway.

2. there is a state $\overline{Y} < 1$ with $R(\overline{Y}) = t$ (or $a(\overline{Y}) = 1$)

3. $\underline{Y} < \overline{Y}$



For $Y < \underline{Y}$, attacking is always successful and rewarding.
=> dominant strategy to attack

For $Y > \overline{Y}$, attacking is never rewarding
=> dominant strategy not to attack

For $\underline{Y} < Y < \overline{Y}$, an attack is rewarding if and only if at least a proportion of $a(Y)$ traders attack.

Note that the state of the world and the shadow exchange rate are common knowledge.
In any Nash equilibrium, strategies are also common knowledge!

Global Game Approach
(Carlsson / van Damme (1993), Morris / Shin (1998, 2003), Heinemann (2000))

Nature selects	Y	random
Players get private information	$X^i = Y + u^i$	random terms u^i are i.i.d.

Assumption: Conditional variance of private signals $Var(X^i \mid Y)$ is sufficiently small

⇒ **Unique equilibrium with threshold X^*,** such that

players with signals $X^i < X^*$ do not attack,

players with signals $X^i > X^*$ do attack.

Marginal player with signal X^* is indifferent.

Additional Equilibrium condition:

$$E\, U^i (\text{attacking} \mid X^*) = E\, U^i (\text{non attacking} \mid X^*)$$

Global Game

Treat the model as a randomly selected model out of a class of models

True state of the world Y is random, $Y \sim$ uniform in $[0,1]$

Players do not know Y.

Players get private information $x^i = Y + u^i$ random terms u^i are i.i.d.

$u^i \sim$ uniform in $[-\varepsilon, +\varepsilon]$, ε is small, $\varepsilon < \min\{\underline{Y}/2, (1-\overline{Y})/2\}$

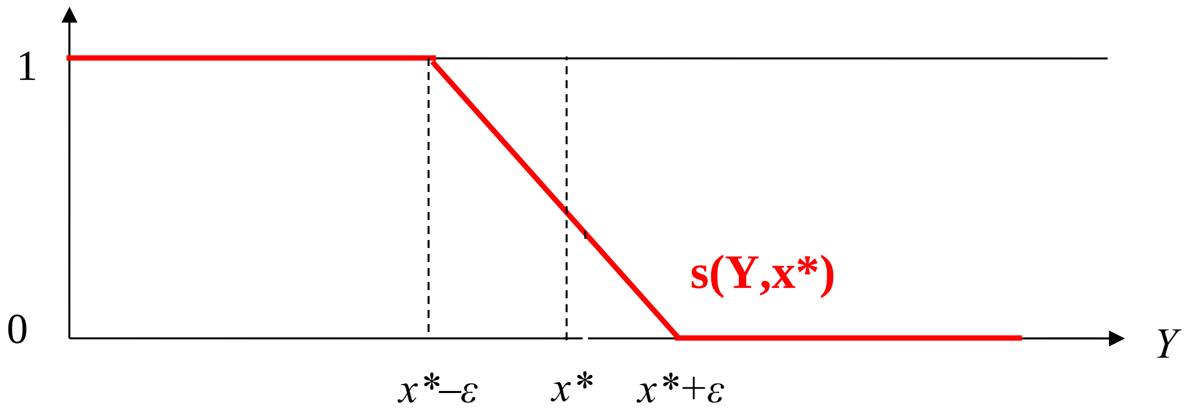
The game is supermodular

Supermodular games have a highest and a lowest equilibrium that can be attained by iterative elimination of dominated strategies (Vives 1990, Milgrom/Roberts 1990).

Apply iterative elimination of dominated strategies => iteration procedures from above and below stop at threshold strategies, such that any player i attacks, if her signal is smaller than the threshold, does not attack if her signal is larger, and is indifferent if her signal equals the threshold.

Let us look at some threshold strategy x^*. A player i attacks if and only if $x^i < x^*$.

The proportion of agents attacking is
$$s(Y, x^*) = \begin{cases} 0 & if \quad Y > x^* + \varepsilon \\ \dfrac{x^* + \varepsilon - Y}{2\varepsilon} & if \quad x^* - \varepsilon < Y < x^* + \varepsilon \\ 1 & if \quad Y < x^* - \varepsilon \end{cases}$$



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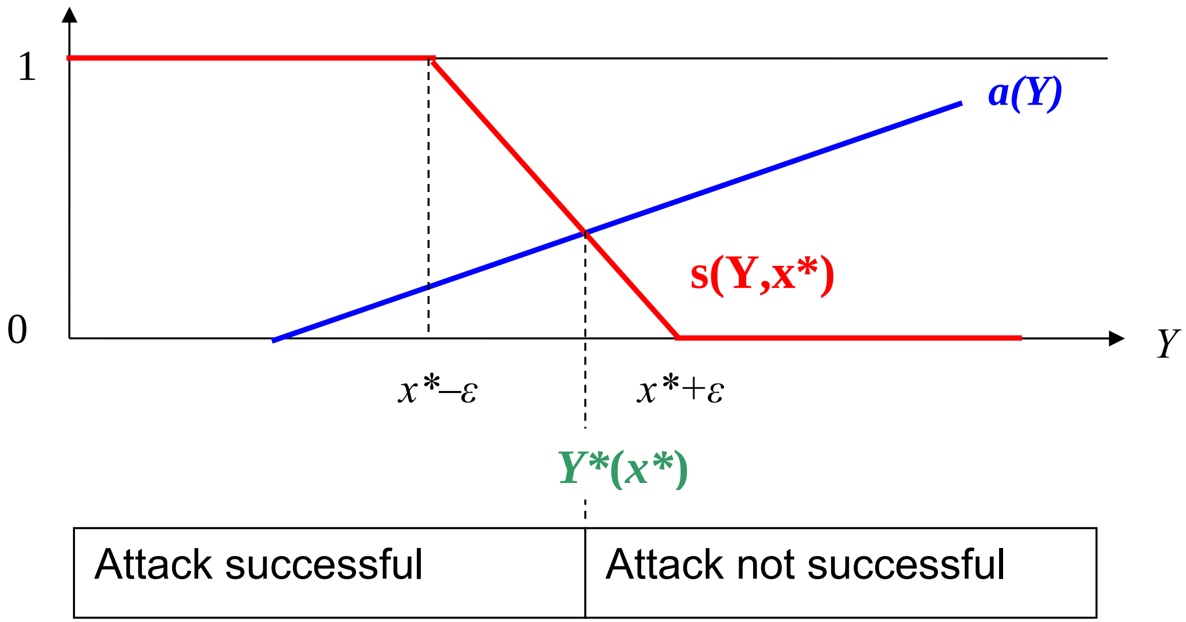


Is this an equilibrium?

Player i prefers attacking if and only if $x^i < x^*$. If $x^i = x^*$ the player is indifferent

Additional equilibrium condition: E U^i (attacking | x*) = E U^i (non attacking | x*)

See Figure 1

Uniqueness?

See Figure 2

Generally, uniqueness depends on distribution.

For uniform distribution, we get a unique equilibrium if ε is small.

For normal distribution, uniqueness requires that Variance of private signals $x^i|Y$ is small compared to variance of prior distribution of Y.

Limit case: $\varepsilon \to 0$ => x* = Y*, determined by $R(Y^*)(1-a(Y^*)) = t$.

Global Game Approach – Some Theoretical Results:

1. Uniform distribution of signals => Equilibrium is unique (Carlsson/van Damme 1993, Morris/Shin 1998, 2003)
2. For $\varepsilon \rightarrow 0$, critical state Y^* converges to Y_0, solution of $(1-a(Y_0))\ R(Y_0)= t$ (Heinemann 2000). Call this limit point the **Global Game Selection (GGS)**
3. $Y \sim N\ (y,\tau^2)$, $X^i = Y + u^i$, $u^i \sim N\ (0,\sigma^2)$

   Equilibrium is unique, provided that $\sigma < \tau^2 a'(Y)\sqrt{2\pi}$ for all Y.

   (Morris/Shin 1999, Hellwig 2002)
4. In a game with just two actions (attack or not): GGS is independent of particular distribution (*noise-independent*) and can be characterized by best response of a player who believes that the proportion of others attacking has a uniform distribution in [0,1]. (Frankel et al. 2001)
5. Uniform distribution: transparency (lowering ε) reduces prior probability of crises (Heinemann/Illing 2002) see Figure 4.

   Normal distribution: Ambiguous effects of public and private info (Rochet/Vives 2002, Metz 2002, Bannier/Heinemann 2005).
6. A well informed large trader increases probability of crises (Corsetti et al. 2004)

7. If a game with more than 2 actions can be decomposed in smaller noise independent games, and the GGS of these smaller games all point towards the same strategy, then this strategy is also the noise independent GGS of the larger game (Basteck, Daniëls, Heinemann, 2013).

Example: n players, m actions: a_1, a_2, a_3, …, a_m, with : $a_j < a_{j+1}$ for all j

Look at the games with the same set of players but only 2 adjacent actions a_j, a_{j+1}.

If there is some j*, s.t. for all restricted games (a_j, a_{j+1}) with $j<j^*$, the GGS is a_{j+1}, and for all games (a_j, a_{j+1}) with $j \geq j^*$, the GGS is a_j, then a_{j^*} is the noise independent GGS of the large game.

Since GGS of 2-action games can be easily calculated, you can also easily calculate the GGS of a noise independent larger game.

If a game is not noise independent, multiple equilibria of CK game are replaced by multiple GGS (depending on distribution). Here the concept is less convincing.

Interpretation of GGS as a refinement theory for common knowledge game:

If variance of private signals approaches zero, in equilibrium each player acts as if she beliefs that the proportion of other players attacking has a uniform distribution in [0,1].

(Laplacian Beliefs)

$\Rightarrow$ **Global Game Selection**

Other refinement theories

- payoff dominant equilibrium
- risk dominant equilibrium
- maximin strategies

Experiment on the speculative attack game

(Heinemann, Nagel, Ockenfels 2004)

1. **People use threshold strategies (as predicted by global games)**
2. **Public information is <u>not</u> destabilizing**
3. **Comparative statics w.r.t. parameters of payoff function as predicted by global-games theory**
4. **Subjects coordinate on strategies that yield a higher payoff than global-game equilibrium (thresholds are lower than predicted)**

Sessions with common information and sessions with private information

15 participants per session (undergraduate students of Goethe Universität Frankfurt and Universitat Pompeu Babra in Barcelona)

Each session consists of 16 rounds,

each round has 10 independent decision situations:

Decision situation:

All sessions:

$Y \in [\,10, 90\,]$ randomly selected (uniform distribution)

Sessions with private information only:

$X^i \mid Y \in [\,Y - 10\,,\, Y + 10\,]$ independently and randomly selected (uniform distribution)

Subjects decide between A and B

- knowing Y in sessions with common information
- knowing X^i in sessions with private information

Payoff for A is certain and either **T=20** or **T=50** ECU (Experimental Currency Units)

We have two treatments per session, each is kept for 8 rounds:

Half of the sessions start with T=20 for the first 8 rounds and switch to T=50 thereafter.

In other sessions: reverse order

Payoff for B is **Y**, if at least $a(Y) = 15 * (80-Y) / Z$ subjects choose B, **zero** otherwise.

"risky action"

(In four sessions Z=100, in others Z=60)

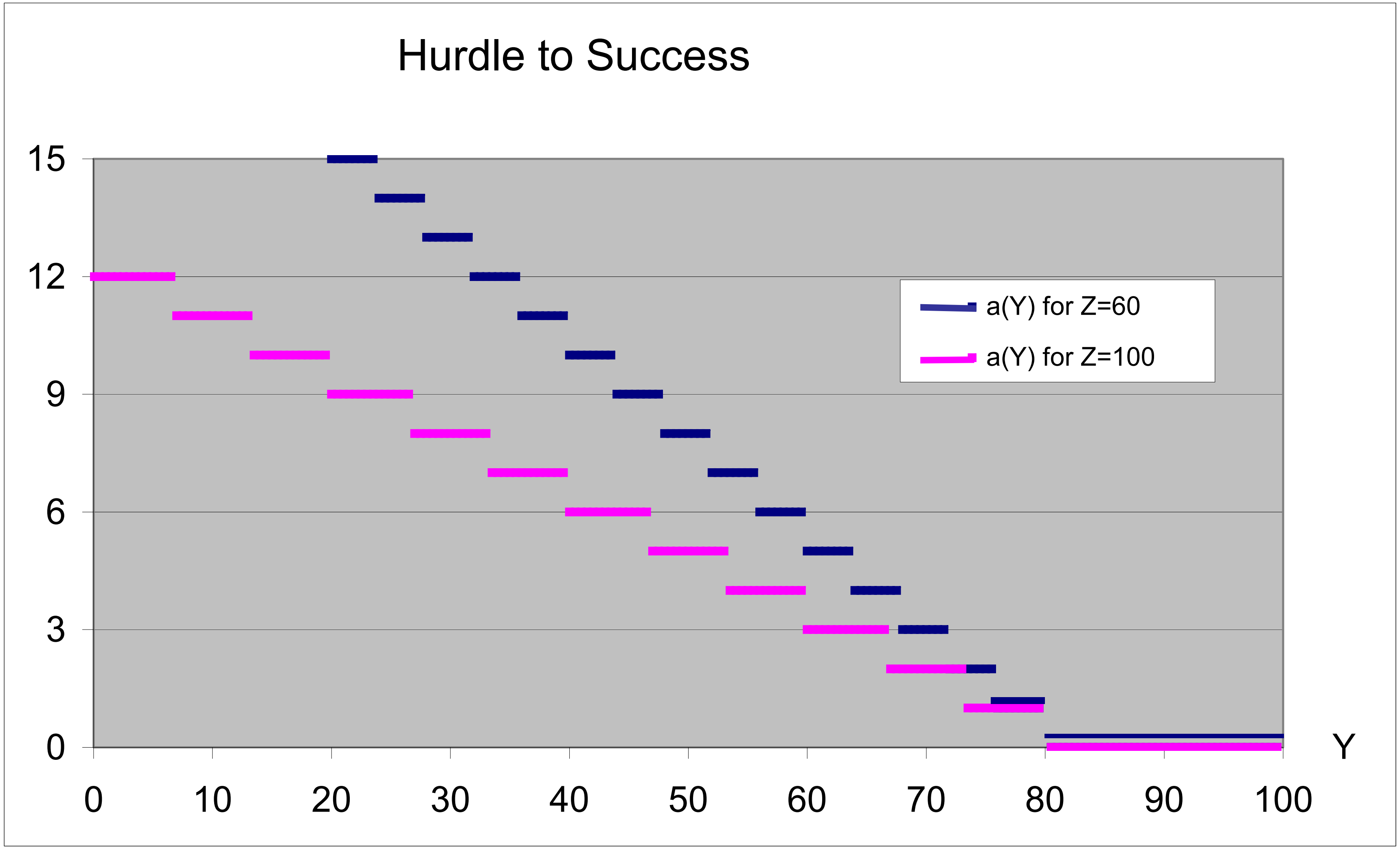
B may be interpreted as **"Attack"**.

Y difference between currency peg and shadow exchange rate (larger **Y** = worse **economic state**)

a(Y) amount of capital needed to enforce devaluation

A may be interpreted as **"non-Attack"**.

T opportunity costs of an attack


Hurdle to Success
a(Y) for Z=60
a(Y) for Z=100
15
12
9
6
3
0
0
10
20
30
40
50
60
70
80
90
100
Y

To calculate the minimal number of B-players needed to get a positive reward for B, subjects get the following table (sessions with Z=60):

If the unknown number Y is in the interval, (Note: Y is between 10 and 90)	Then at least … of the 15 participants (including yourself) must select B, in order to get a positive payoff
20,00 to 23,99	15
24,00 to 27,99	14
28,00 to 31,99	13
32,00 to 35,99	12
36,00 to 39,99	11
40,00 to 43,99	10
44,00 to 47,99	9
48,00 to 51,99	8
52,00 to 55,99	7
56,00 to 59,99	6
60,00 to 63,99	5
64,00 to 67,99	4
68,00 to 71,99	3
72,00 to 75,99	2
76,00 to 90,00	1

Information phase:

Each subject gets to know for each of the 10 decision situations

- the number Y
- how many subjects chose B
- how her payoff changed by her decision.

Payments:

In sessions with Z=100: 1000 ECU = 4 DM

In sessions with Z = 60: 1000 ECU = 5 DM (Frankfurt) or 300-400 Ptas. (Barcelona)

Average payments between 14.30 and 22.50 €, duration 90-120 minutes per session.

Additional sessions:

40 periods with T = 50: 1000 ECU = 1 €

High stake sessions 1 ECU = 1 € for one selected situation from each of the 2 stages

Participants:

Students from Goethe-University Frankfurt am Main and from University Pompeu Fabra in Barcelona, mainly economics undergraduates, invited by leaflets, posters and an e-mail to all students with account at the economics department in Frankfurt.

Place:

Experiment were run in a PC-pool with separated working spaces in Frankfurt and in the LEEX laboratory in Barcelona.

Software:

We used z-Tree, developed by Urs Fischbacher (University of Zürich).

Session Overview

Z	Secure payoff T	Location	session type	Number of sessions with Public information	Private information
100	1st stage 20 2nd stage 50	Frankfurt	standard	1	1
100	50 / 20	Frankfurt	standard	1	1
60	20 / 50	Frankfurt	standard	1	2
60	20 / 50	Barcelona	standard	3	3
60	50 / 20	Frankfurt	standard	2	2
60	50 / 20	Barcelona	standard	3	3
Control sessions:					
60	20 / 50	Frankfurt	experienced	1	
60	50 / 20	Frankfurt	experienced	1	
60	50	Barcelona	40 periods		2
60	20 / 50	Barcelona	high stake		1
60	50 / 20	Barcelona	high stake	1	
Total number of sessions				14	15

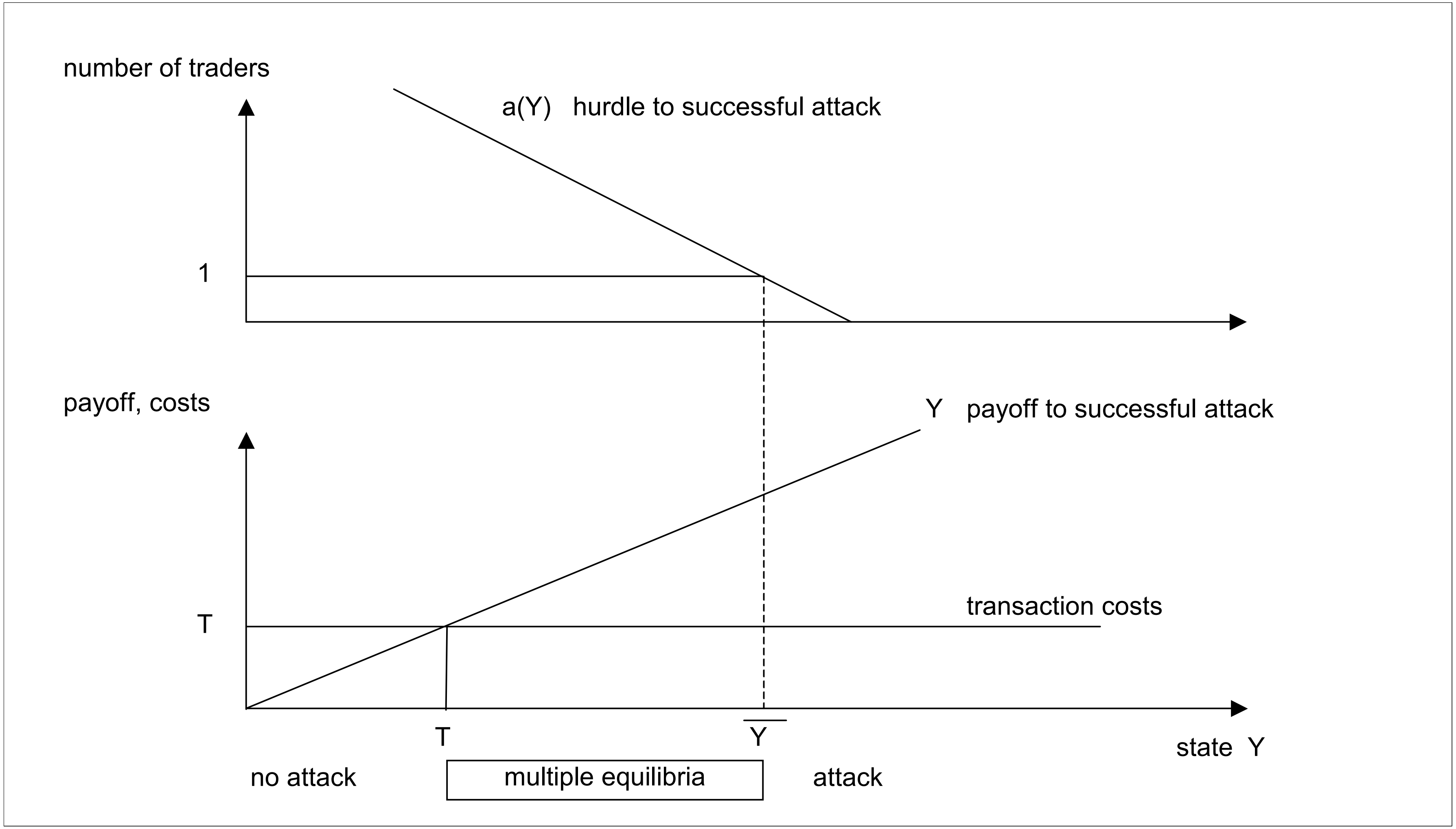


Figure 1. The speculative attack game. If at least a(Y) traders attack, attacking traders receive a payoff Y-T. Otherwise they loose T.

Game with common information (CI)

Payoff dominant equilibrium:

Choose A for $Y < T$ and B for $Y > T$

Maximin strategy:

Choose A for $Y < \overline{Y}$ and B for $Y > \overline{Y}$

Global Game Solution:

Choose A for $Y < Y_0$ and B for $Y > Y_0$

$T < Y_0 < \overline{Y}$

Game with private information (PI)

Unique equilibrium:

Choose A for $X^i < X^*$ and B for $X^i > X^*$

$T < X^* < \overline{Y}$

Theoretical Predictions

Treatments / Equilibrium Theories		T=20, Z=100	T=20, Z=60	T=50, Z=100	T=50, Z=60
CI game Payoff dominant equilibrium	T	20	20	50	50
Maximin equilibrium	$\overline{Y}$	73.33	76.00	73.33	76.00
Global Game solution	Y_0	33.33	44.00	60.00	64.00
Risk dominant equilibrium		34.55	44.00	62.45	67.40
Limiting logit equilibrium		33.07	48.00	51.48	56.00
PI game Unique equilibrium	X*	32.36	41.84	60.98	66.03

Table 2. Theoretical equilibrium threshold states or signals for the parameters T and Z, and n=15.

Results:

1. Threshold Strategies

More than 90% of all subjects played threshold strategies.

In last round at least 13 out of 15 subjects played threshold strategies.

Theory: In PI-game equilibrium strategies are threshold strategies.

In CI-game there are many other equilibria.

Evidence: There is no significant difference between proportion of threshold strategies in sessions with PI and CI.

Explanation: Non-threshold strategies are not robust against strategic uncertainty

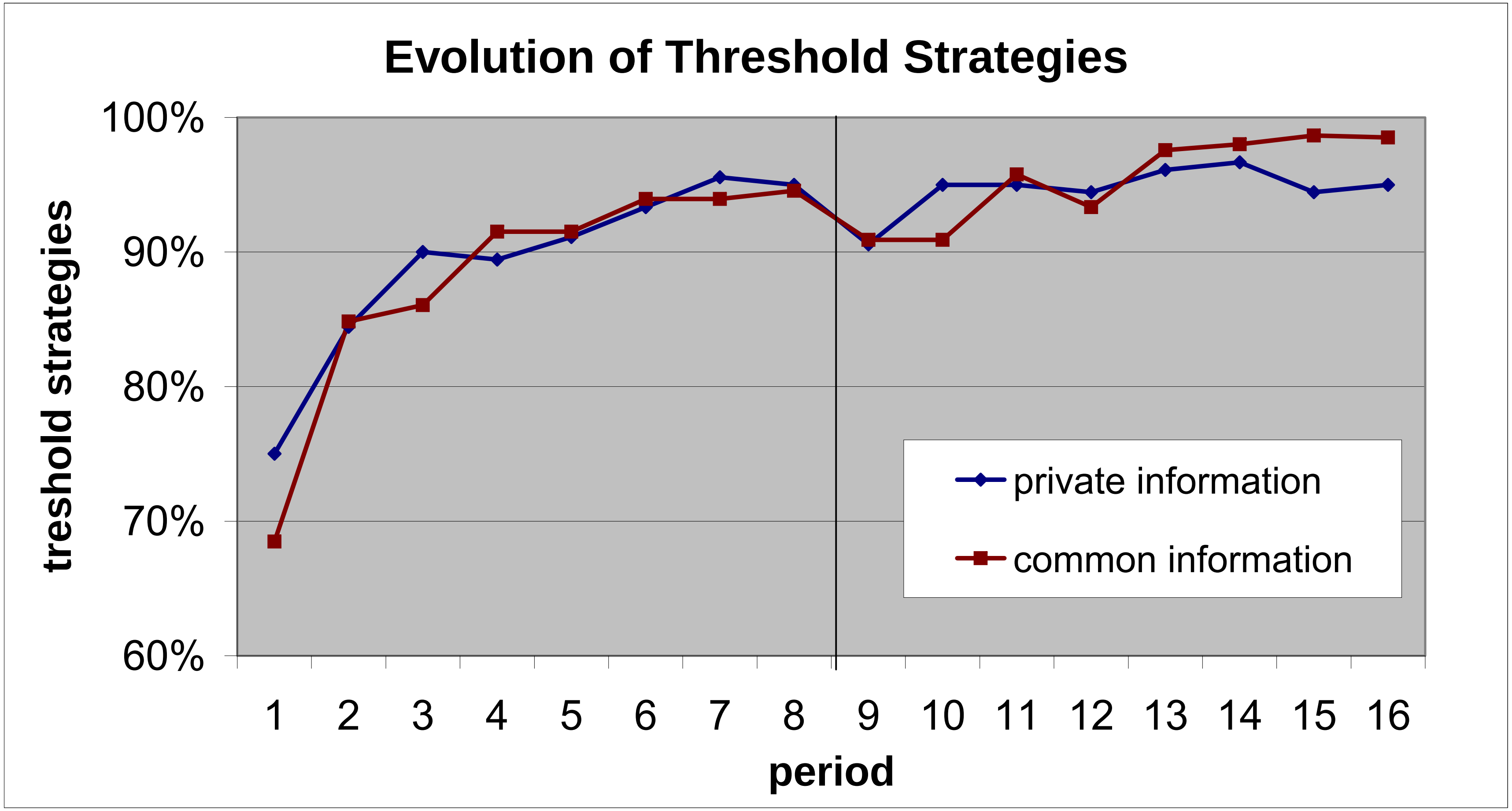
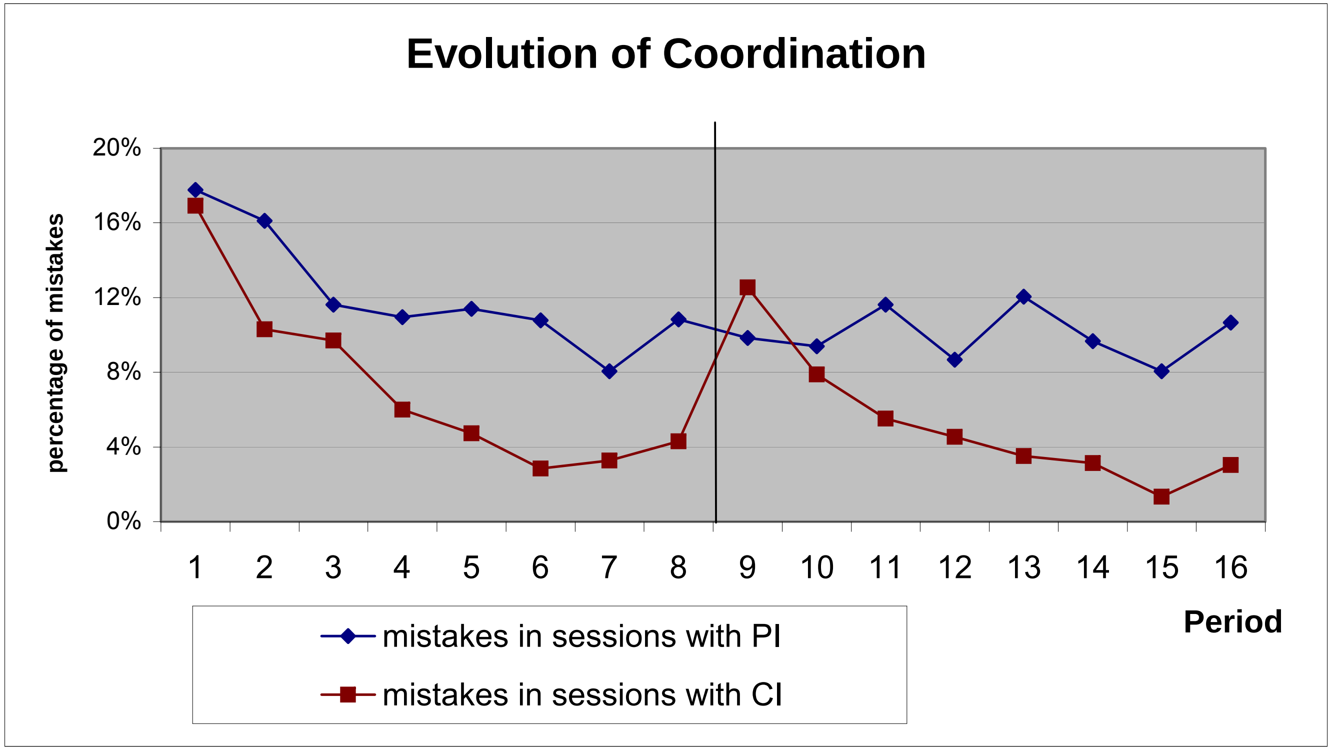


Figure 4. Percentage of inexperienced subjects, whose behavior was consistent with undominated threshold strategies.

2. Evolution of Coordination

Two kinds of mistakes: 1. choose B and receive zero (failed attack)

2. choose A when B would have been successful (missed opportunity to attack)



The difference is about the size that can be explained by incomplete information in PI-setting.

3. Thresholds to Crises

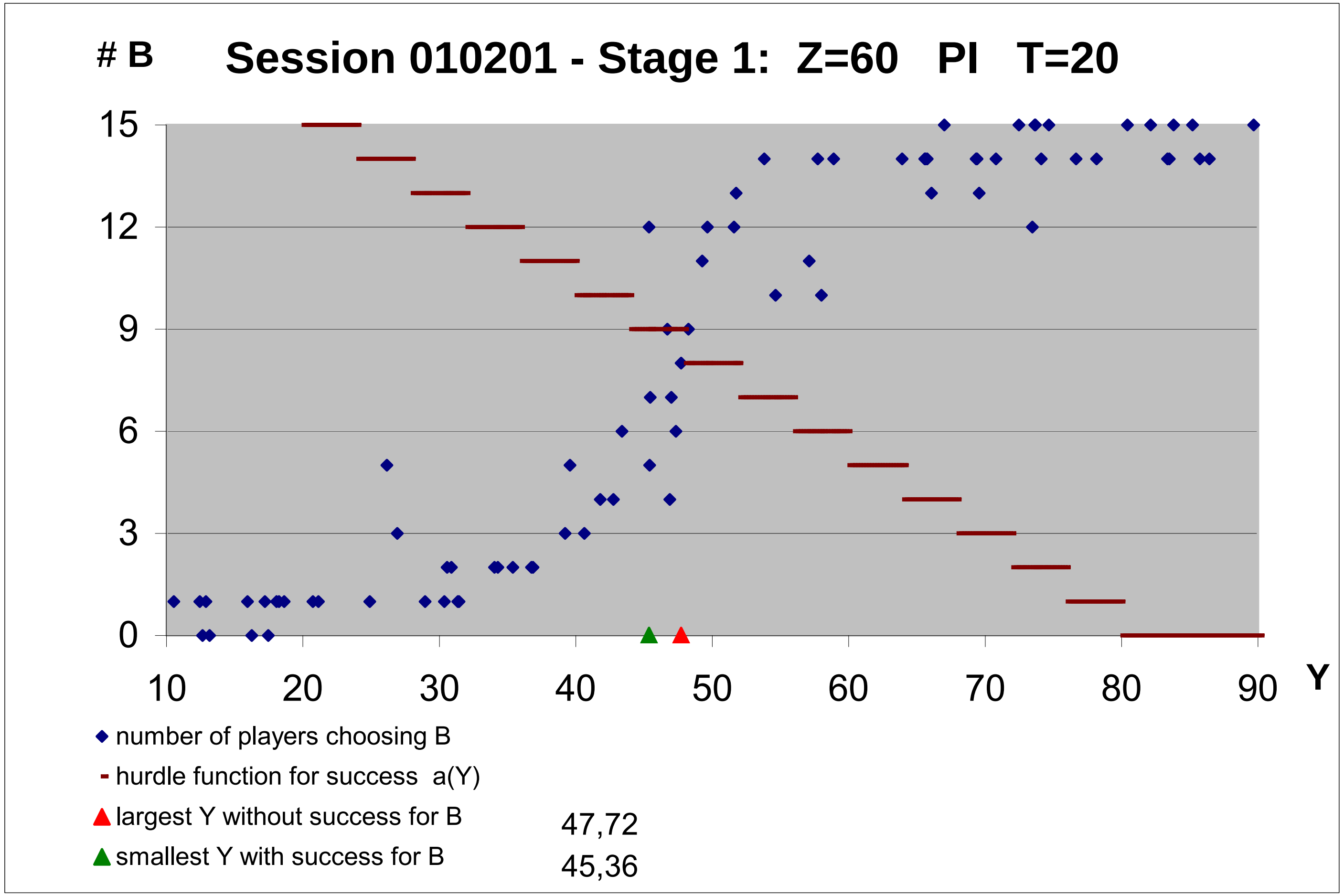


Figure 5. Data from one session and stage show 80 randomly selected states and associated numbers of subjects who chose B. All data points on or above the hurdle function are successful attacks.

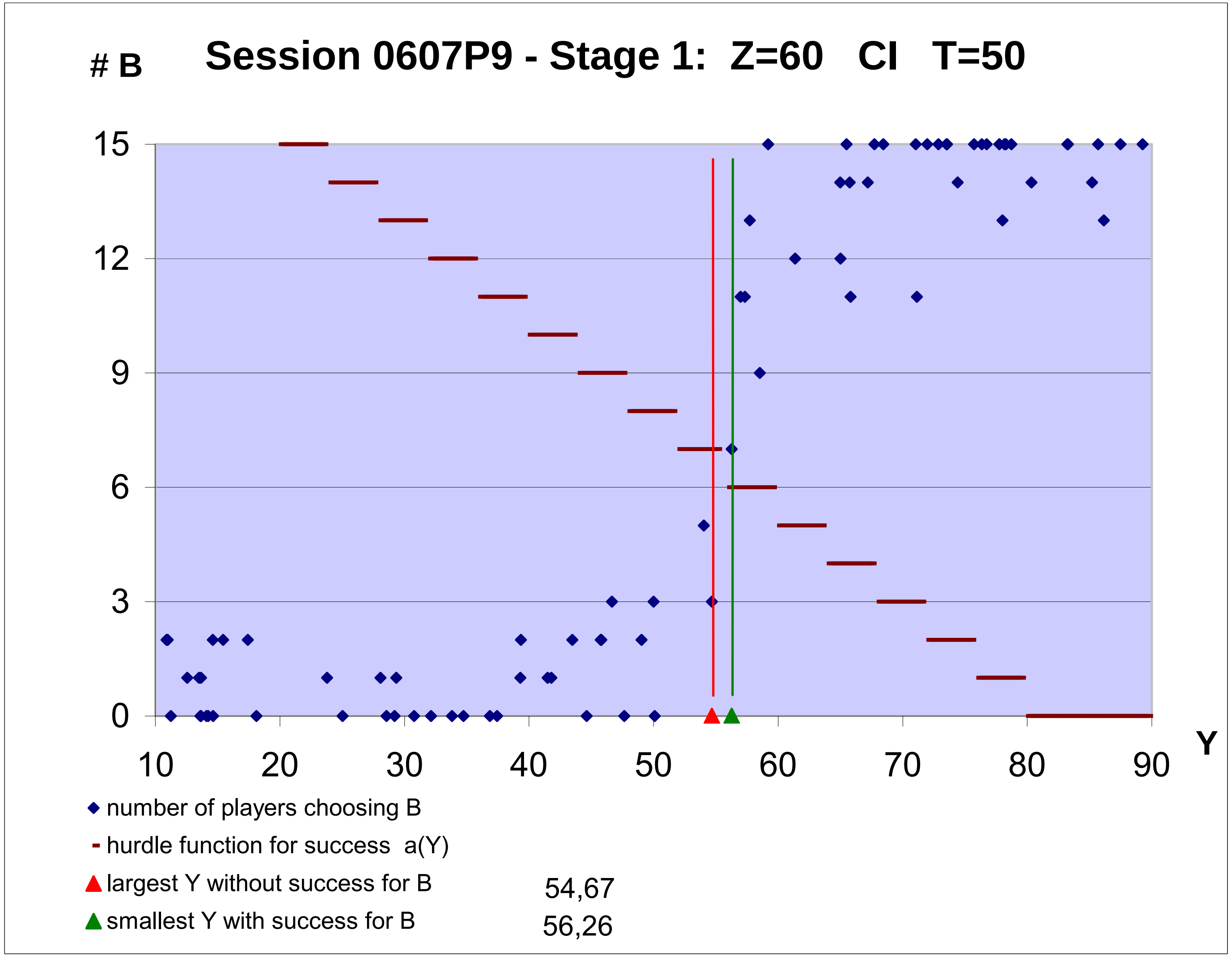


Figure 2. Combined data from all eight periods of one stage of a session with common information. In this example there is complete separation of states with failed and successful attacks.

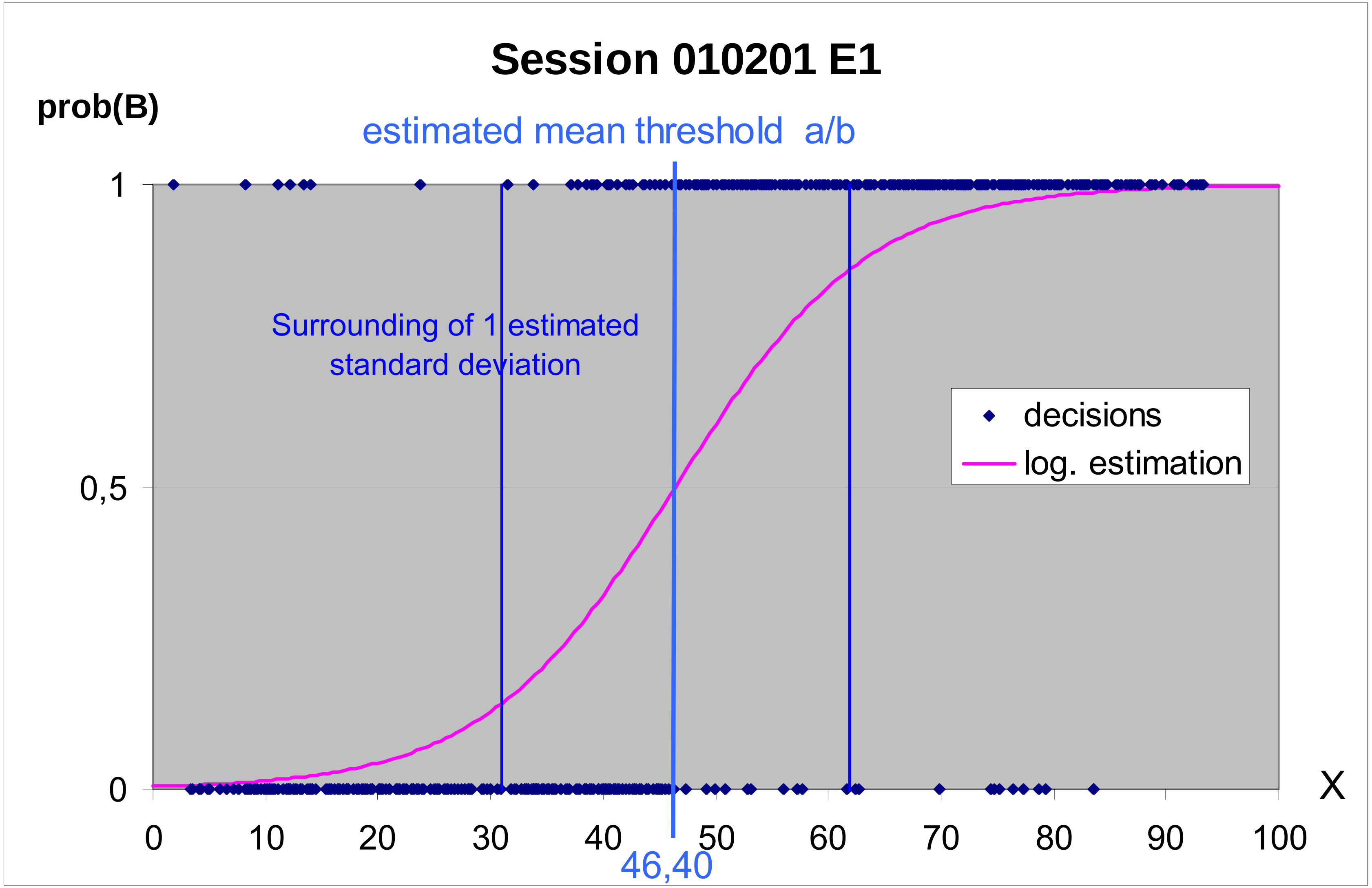
4. Estimation of average thresholds

Estimation of a logistic distribution that approximates data of the last four rounds in each treatment

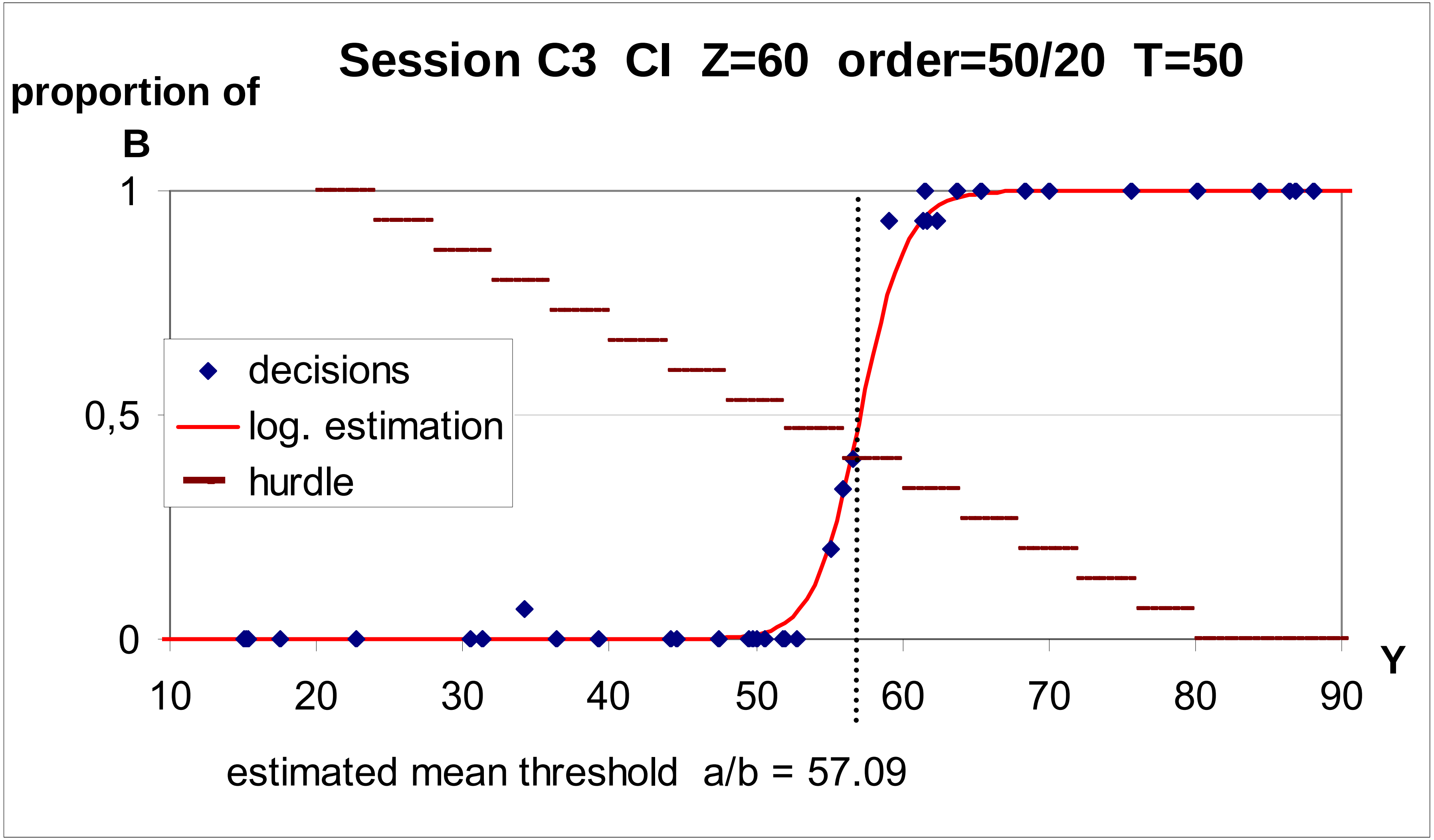
Prob (B) = 1 / (1+exp(a-bx))

Estimate parameters a and b, using logistic regression

estimated mean threshold a/b
estimated standard deviation $\pi / (b \sqrt{3})$



Session with private Information



Session with common information

Session	Type	Location	Z	Infor-mation	Order	T	Parameter estimation a	b	Estimated mean a/b	Estimated standard deviation
P 1	standard	Frankfurt	100	PI	20/50	20	5.07	0.155	32.76	11.72
						50	11.13	0.196	56.77	9.25
P 2	standard	Frankfurt	100	PI	50/20	50	12.78	0.237	53.90	7.65
						20	9.88	0.370	26.71	4.90
C 1	standard	Frankfurt	100	CI	20/50	20	10,32	0.311	33.21	5.84
						50	67.43	1.265	53.31	1.43
C 2	standard	Frankfurt	100	CI	50/20	50	10,37	0.198	52.37	9.16
						20	15.16	0.750	20.22	2.42
P 3	standard	Frankfurt	60	PI	20/50	20	5.67	0.123	46.04	14.73
						50	7.15	0.119	60.32	15.30
P 4	standard	Frankfurt	60	PI	50/20	50	7.85	0.134	58.59	13.53
						20	7.29	0.157	46.57	11.59
P 5	standard	Frankfurt	60	PI	50/20	50	12.79	0.211	60.71	8.61
						20	11.92	0.289	41.22	6.27
P 6	standard	Frankfurt	60	PI	20/50	20	7.40	0.166	44.57	10.93
						50	18.37	0.305	60.29	5.95
C 3	standard	Frankfurt	60	CI	20/50	20	9.13	0.239	38.20	7.59
						50	36.28	0.635	57.09	2.85
C 4	standard	Frankfurt	60	CI	50/20	50	8.08	0.177	45.67	10.25
						20	10.32	0.314	32.81	5.77
C 5	standard	Frankfurt	60	CI	50/20	50	330.25	6.402	51.58	0.28
						20	14.24	0.443	32.16	4.10
P 7	standard	Barcelona	60	PI	20/50	20	7.94	0.185	42.84	9.79
						50	7.82	0.144	54.16	12.57
P 8	standard	Barcelona	60	PI	50/20	50	14.09	0.264	53.35	6.87
						20	10.52	0.291	36.18	6.24
P 9	standard	Barcelona	60	PI	20/50	20	7.51	0.167	44.86	10.83

						50	16.68	0.326	51.24	5.57
P 10	standard	Barcelona	60	PI	50/20	50	10.32	0.188	55.00	9.66
						20	9.88	0.259	38.14	7.00
P 11	standard	Barcelona	60	PI	20/50	20	8.08	0.188	43.09	9.67
						50	14.82	0.247	60.01	7.35
P 12	standard	Barcelona	60	PI	50/20	50	13.45	0.237	56.73	7.65
						20	8.02	0.231	34.78	7.86
C 6	standard	Barcelona	60	CI	20/50	20	6.33	0.162	39.10	11.20
						50	11.35	0.223	50.87	8.13
C 7	standard	Barcelona	60	CI	50/20	50	23.33	0.430	54.25	4.22
						20	17.61	0.490	35.96	3.70
C 8	standard	Barcelona	60	CI	20/50	20	25.71	0.639	40.26	2.84
						50	73.82	1.356	54.44	1.34
C 9	standard	Barcelona	60	CI	50/20	50	8.75	0.158	55.49	11.50
						20	14.36	0.340	42.22	5.33
C 10	standard	Barcelona	60	CI	20/50	20	6.31	0.154	40.94	11.77
						50	10.11	0.176	57.50	10.31
C 11	standard	Barcelona	60	CI	50/20	50	21.36	0.411	51.91	4.41
						20	17.59	0.477	36.92	3.81
E 1	exper-ienced	Frankfurt	60	CI	20/50	20	18.19	0.557	32.66	3.26
						50	28.83	0.505	57.06	3.59
E 2	exper-ienced	Frankfurt	60	CI	50/20	50	85.88	1.707	50.32	1.06
						20	16.09	0.518	31.06	3.50
L 1	long	Barcelona	60	PI	–	50	22.78	0.378	60.36	4.81
L 2	long	Barcelona	60	PI	–	50	19.96	0.357	55.96	5.09
H 1	high stake	Barcelona	60	PI	20/50	20	8.38	0.148	56.79	12.29
						50	10.12	0.156	65.07	11.66
H 2	high stake	Barcelona	60	CI	50/20	50	37.79	0.668	56.58	2.72
						20	46.56	6.051	46.56	6.05

5. **Analyzing observed average thresholds**

5.1. summary statistic

A Crisis occurs whenever Y > Y*. Lower threshold to crises <=> higher probability of crises

Treatment	T=20, Z=100	T=20, Z=60	T=50, Z=100	T=50, Z=60
Payoff dominant equilibrium of CI game	20	20	50	50
Global game solution for CI game	33.33	44.00	60.00	64.00
Risk dominant equilibrium	34.55	44.00	62.45	67.40
Maximin strategy	73.33	76.00	73.33	76.00
Unique equilibrium of PI game	32.36	41.84	60.98	66.03
Mean Threshold to Success in sessions with CI	26.71	37.62	52.84	53.20
Mean Threshold to Success in sessions with PI	29.73	41.83	55.33	54.04
High stake session with PI		55.97		62.69
High stake session with CI		46,91		57,15

Table 2. Theoretical equilibrium thresholds and observed mean thresholds

5.2. Regressions on estimated average thresholds (based on standard sessions)

We have 2 x 2 x 2 x 2 x 2 design (T, Z, location, info, order each take on 2 possible values)

Dummy variables

T	0: payoff for secure action T=20	1: T=50
Z	0: session with Z=100	1: session with Z=60
TZ	0: if T=20 or Z=100	1: if T=50 and Z=60
Loc(ation)	0: session in Barcelona	1: session in Frankfurt
Info(rmation)	0: session with CI	1: session with PI
Ord(er)	0: session starting with T=50	1: session starting with T=20
TO	0: if Order=0 or T=20	1: if Order=1 and T=50

Average threshold = $b_0 + b_1$ T + b_2 Z + b_3 TZ + b_4 Loc + b_5 Info + b_6 Ord + b_7 TO

Estimate parameters $b_0 - b_7$ with OLS

Average threshold = 22.6 + 27.6 T + 12.4 Z – 10.6 TZ + 1.2 Loc + 3.6 Info + 5.3 Ord – 3.5 TO

(t-values) (10.8) (11.2) (6.5) (-4.2) (1.1) (3.8) (3.9) (-1.9) R^2=0.91

1. Thresholds rise in the payoff for the secure action .

2. Thresholds rise, if the hurdle to success of the risky action is increased.

- Empirical behavior reacts to changes in parameters in the same way as Laplacian belief equilibrium.

⇒ **The concept can be used for qualitative comparative statics**

3. With common information (CI) threshold tends to be smaller than with private information (PI).

- CI reduces strategic uncertainty and thereby increases the ability of a group to achieve efficient coordination.

⇒ **Public information leads to higher probability of speculative attack and to a lower probability of inefficient liquidation of a firm.**

4. In session where we started with paying 20 for the secure action both thresholds tend to be lower than in sessions, where we started with paying 50 for this action.

- This evidence contradicts hypothesis of a numerical inertia in thresholds.
- It is consistent with numerical inertia in increments of thresholds above payoff dominance.

5. Interaction term TO reveal that order effect is stronger for T = 20 than for T = 50.
6. Location is not significant

Statistical Analysis shows:

Threshold to crisis is 3.6 higher for CI than for PI

=> **Probability of a crisis is higher with common (public) information**.

Threshold to crisis rises in T and falls in Z

As predicted by global game solution and risk dominance

=> **Interpretation:**

Transaction costs and capital controls lower the probability of a crisis.

Threshold to crisis is higher (in both treatments) if we start with T=50

This contradicts hypothesis of numerical inertia in thresholds.

Explanation: Subjects decide on thresholds using a numerical increment on threshold of payoff dominant equilibrium. Evidence supports numerical inertia in those increments.

$$Y^* = T + d^*$$

7. Predictability of Crises

Theory says

Private information $\Rightarrow$ unique equilibrium $\Rightarrow$ attacks are predictable

Public information $\Rightarrow$ multiple equilibria $\Rightarrow$ attacks are not predictable

Conclusion: Public information may destabilize the economy

Experimental evidence:

Dispersion of estimated mean thresholds is the same for both conditions

In both scenarios 87% of data variation (in mean thresholds) can be explained by controlled variables.

Average value of residuals is about the same (3.63 with CI and 3.44 with PI

Width of the interval for which attacks are not predictable is higher with private information, but this is merely due to randomness of signals.

=> Predictability of crises (by an outside observer, i.e. analyst) is higher with public than with private information, because of the randomness of signals under PI.

There is no evidence that public information might be destabilizing

8. Testing Equilibrium theories

Hypotheses: Estimated mean individual thresholds coincide with thresholds of

a. payoff dominant equilibrium

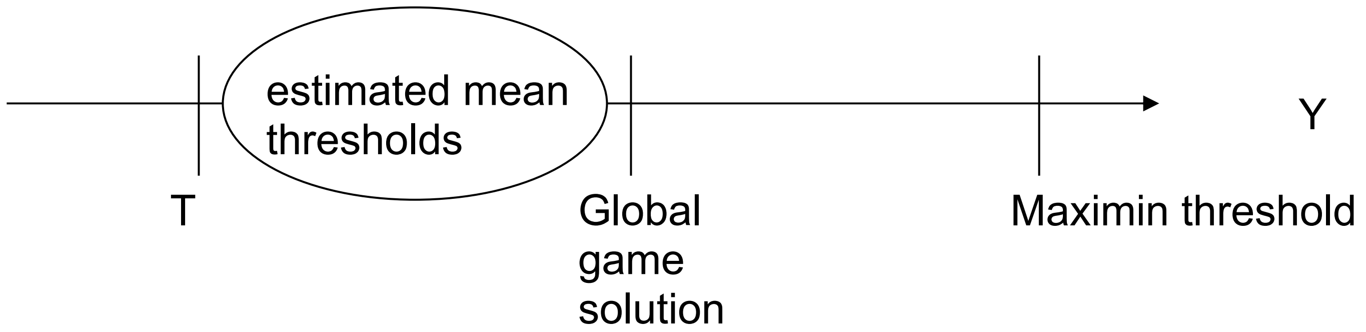
b. risk dominant equilibrium

c. global game solution (Laplacian belief equilibrium)

d. maximin strategies

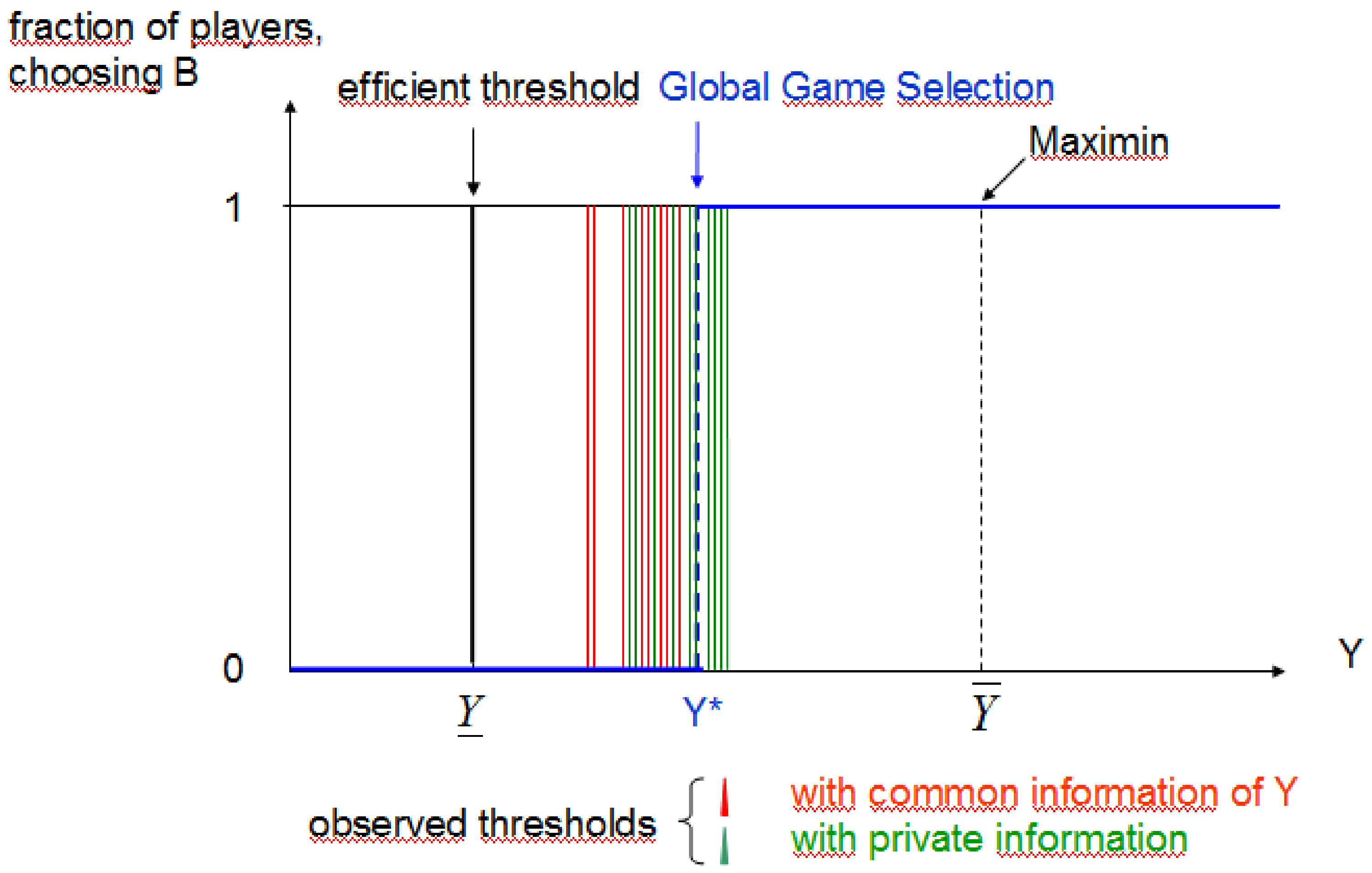
In sessions with CI all of these refinements can be rejected by 2-sided F-tests.

Observed behavior: In sessions with CI, estimated mean individual thresholds are always between thresholds of payoff dominant equilibrium and global game solution



Equilibria and observations in the experiment

T=20, Z=60, Y*=44



Other Theories of Belief Formation

Suppose a subject believes that other subjects choose action B with some probability p.

Then the best response is to switch at some threshold Y*(p).

For p=2/3 we get

Treatment	Z=100, T=20	Z=60, T=20	Z=100, T=50	Z=60, T=50
Y*(p)	23.5	40.0	50.0	52.0
Observed mean thresholds in CI sessions	26.71	37.62	52.84	53.20

Predictions of p $\in$ (0.6, 0.7) cannot be rejected in sessions with CI. In sessions with PI predictions can be rejected for any p.

Further Results:

In sessions with common information subjects tend to coordinate within few rounds on a common threshold that is between payoff-dominant equilibrium and Global-Game Solution.

We never observed an equilibrium that requires coordination of more than 12 out of 15 subjects.

Dispersion of estimated thresholds across sessions was the same for CI and PI
- This contradicts the theoretical prediction that with CI coordination may be subject to arbitrary self-fulfilling beliefs

$\Rightarrow$ **There is no destabilizing effect of public information**

High stake sessions yield higher thresholds:

Explanation: Risk aversion

Long sessions do not show convergence towards equilibrium, even though equilibrium is the unique solution of iterated elimination of dominated strategies.

Explanation: Subjects deviate towards strategies that yield higher payoffs. Although not in equilibrium, they all profit from this deviation.

Qu (2013): 12 subjects simultaneously decide whether to invest.
Payoff for successful investment 1000, failed investment 0, no investment 500

Investment is successful if proportion of subjects investing is at least Y.

Random variable Y~N(50,100). Subjects receive private signals $X^i = Y + d^i$, d^i ~N(0,20)

Treatments - **control**

- **cheap talk**: before deciding to invest, subjects announce their "intention".
  Number of subjects who announce "I will invest" is publicly revealed.

- **market treatment:** before deciding to invest, subjects can trade 2 assets that pay conditional on investment being successful or not. Price is publicly revealed.

Market treatment: price aggregates private signals. Subjects use price as a coordinating device. But, they coordinate on a strategy that is <u>less</u> efficient than the average strategy in the control treatment.

Cheap talk treatment: most subjects announce that they invest except for very high realizations of Y. The total number of investment intentions serves as a coordinating device (as the price in the market treatment), but under cheap talk, they coordinate on an equilibrium that is <u>more</u> efficient the average strategy in the control treatment.