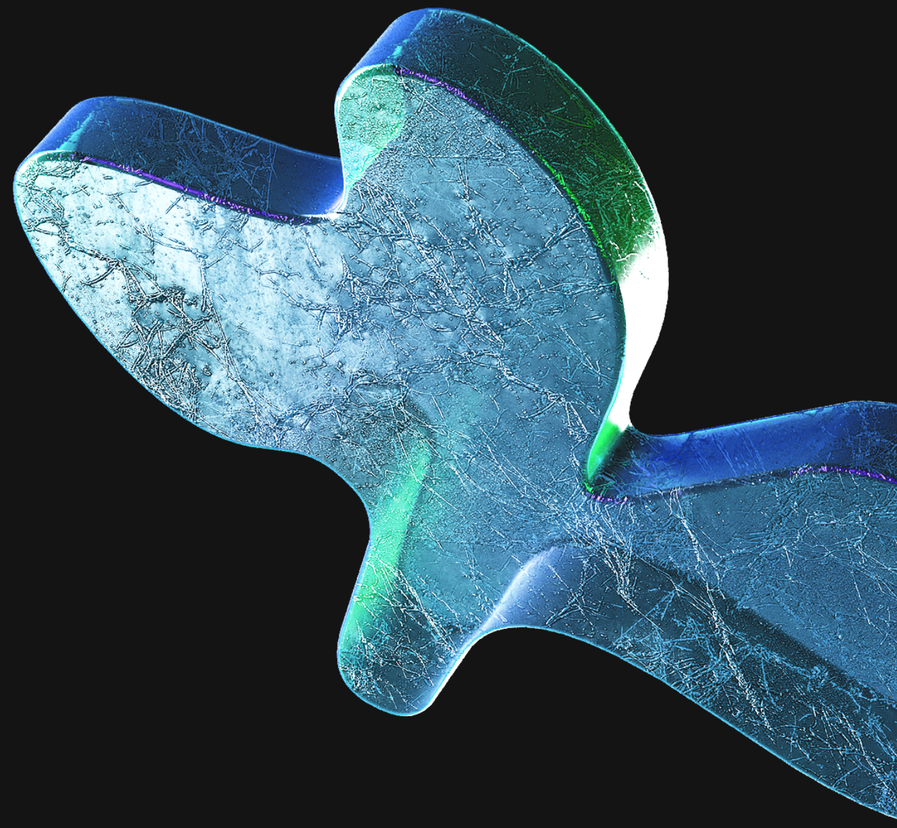
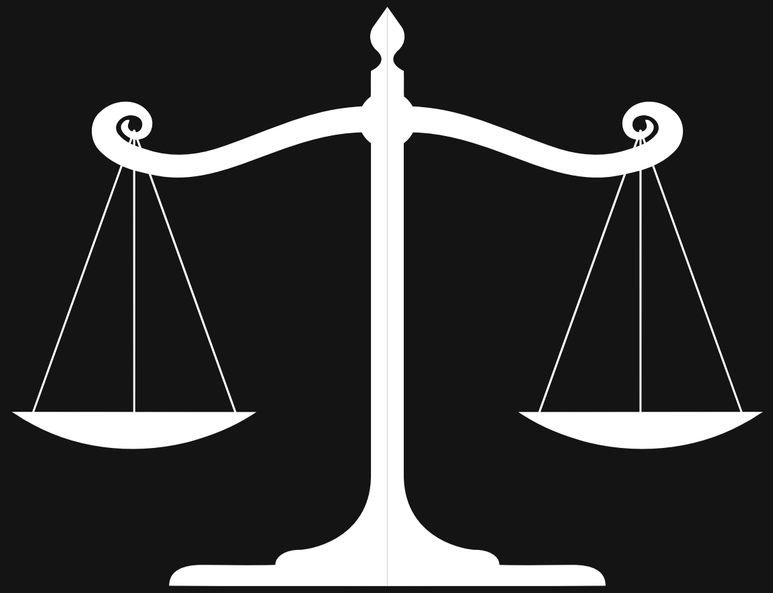


Nash equilibrium



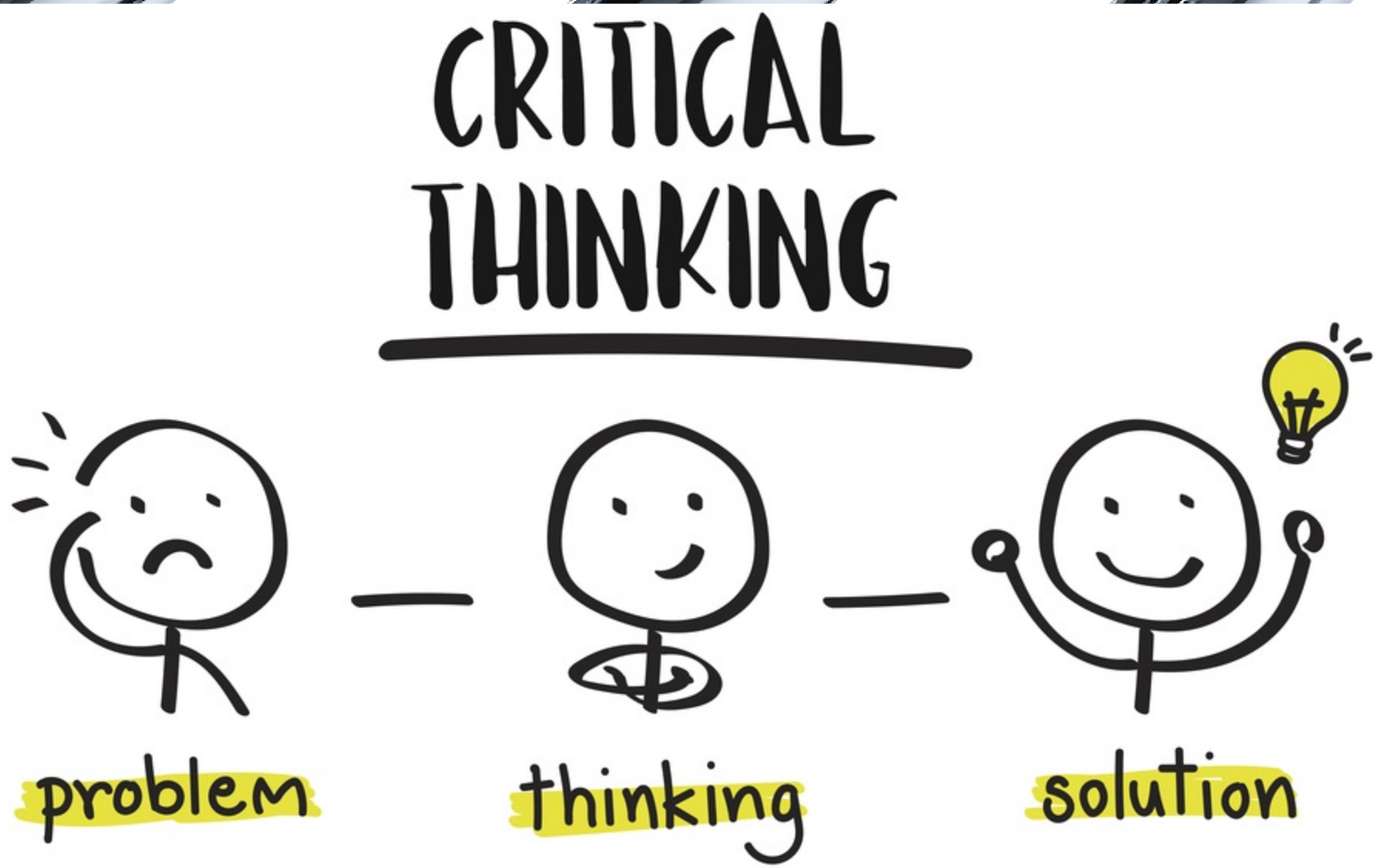
- THEORY OF GAMES
- NASH EQULIBRIUM
- NASH EQUILIBRIUM – AND THE FORMATION OF WORLD OIL PRICES

Nash Equilibrium



ONE OF THE MOST IMPORTANT COMPONENTS OF THE ANALYSIS OF VARIOUS ASPECTS OF HUMAN ACTIVITY, INCLUDING ECONOMICS, SOCIOLOGY AND MILITARY DEFENSE.

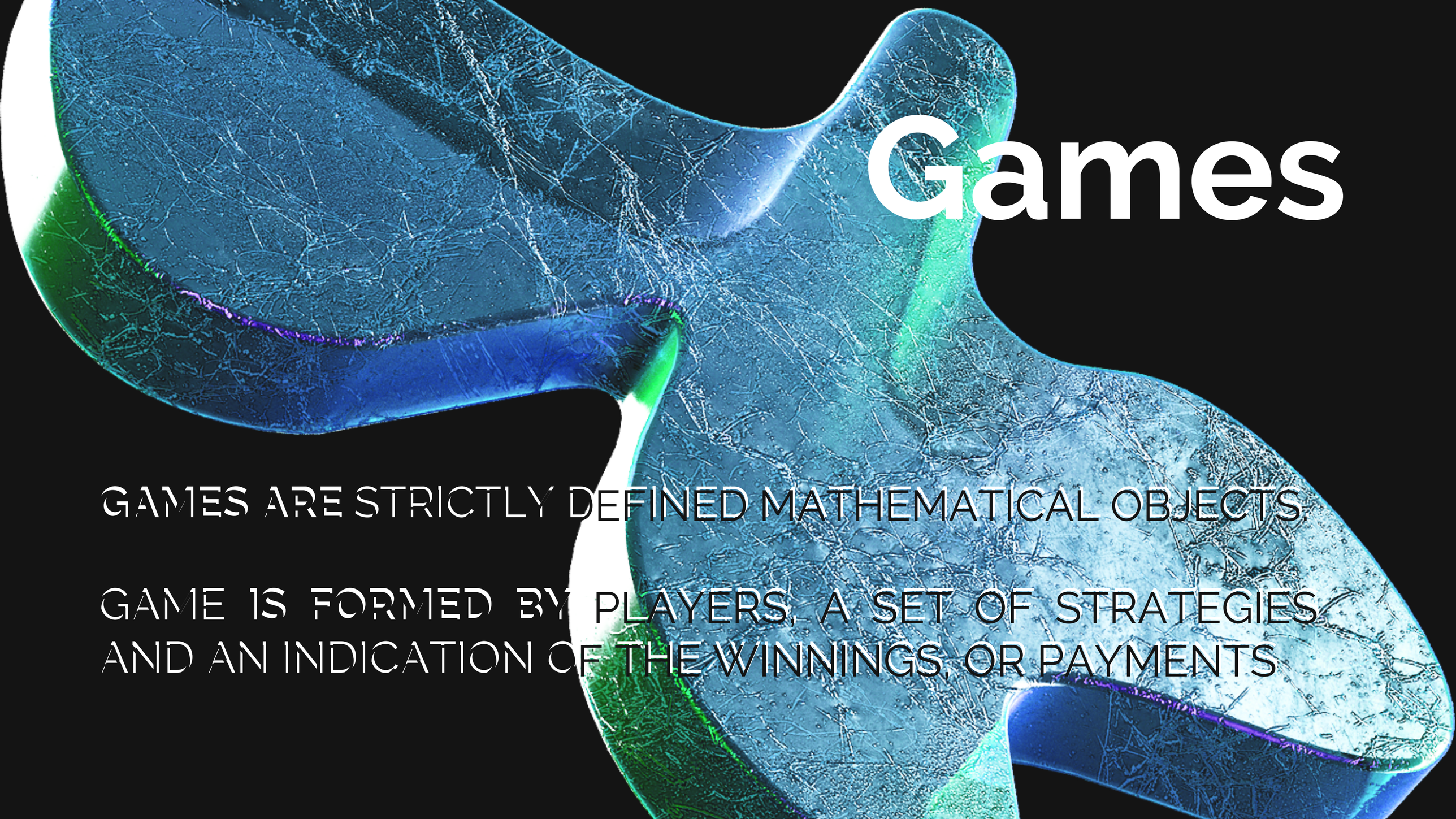
Concept of reasoning modeling





Game theory

IT'S A BRANCH OF APPLIED MATHEMATICS, MORE PRECISELY, OPERATIONS RESEARCH. IT'S USED IN INTERNATIONAL RELATIONS, ECONOMICS, SOCIOLOGY, POLITICAL SCIENCE, PSYCHOLOGY, ETHICS, JURISPRUDENCE AND OTHERS.

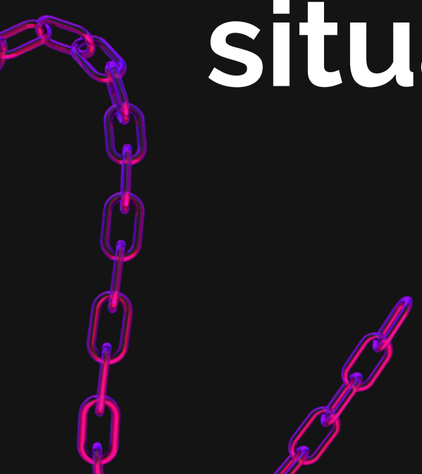


Games

GAMES ARE STRICTLY DEFINED MATHEMATICAL OBJECTS.

GAME IS FORMED BY PLAYERS, A SET OF STRATEGIES
AND AN INDICATION OF THE WINNINGS, OR PAYMENTS

Characterizing features of the game as a mathematical model of the situation





1. THE PRESENCE OF SEVERAL PARTICIPANTS;

2. THE UNCERTAINTY OF THE BEHAVIOR OF THE PARTICIPANTS

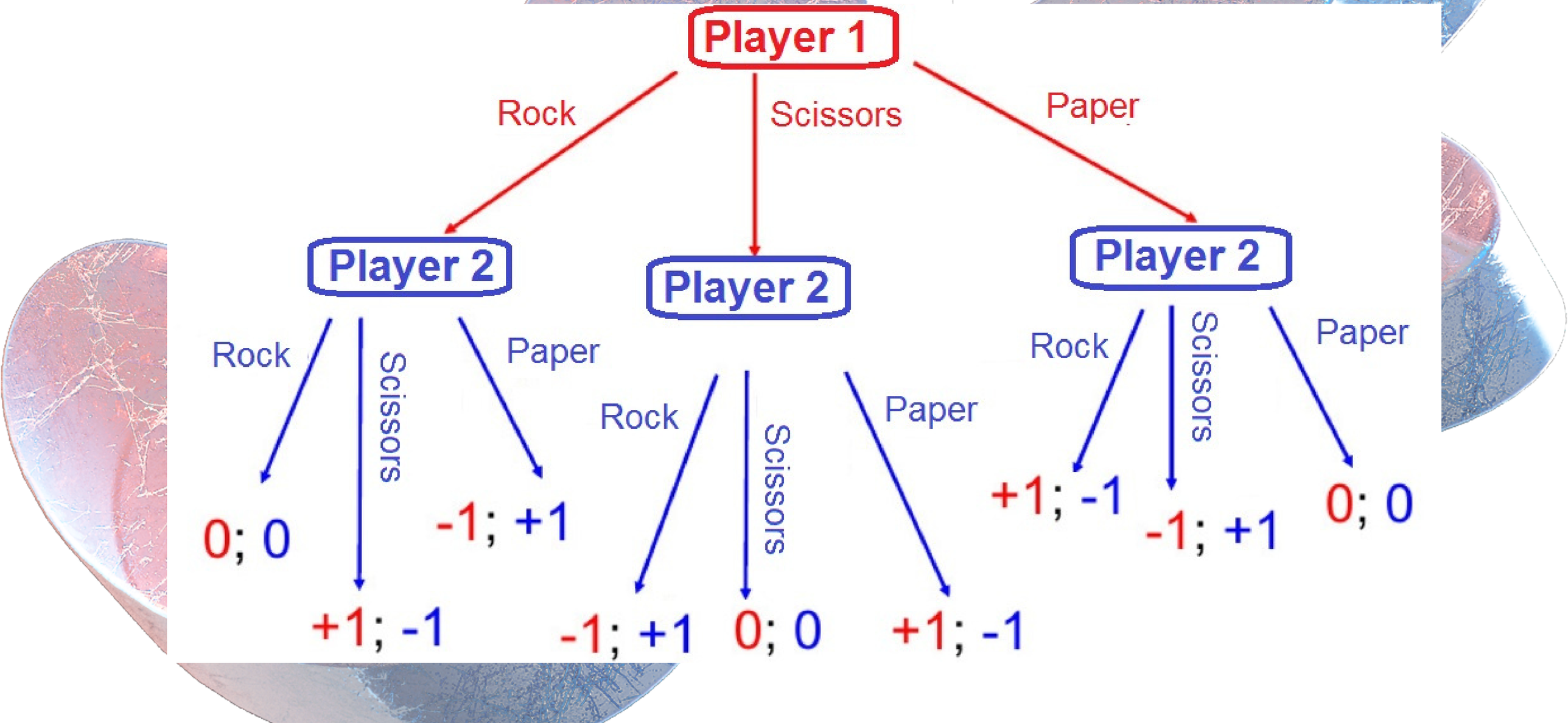
3. THE DIFFERENCE OF INTERESTS OF THE PARTICIPANTS

4. THE INTERCONNECTEDNESS OF THE BEHAVIOR OF THE PARTICIPANTS

since the result obtained by each of them depends on the behavior of all participants

5. THE PRESENCE OF RULES OF CONDUCT KNOWN TO ALL PARTICIPANTS.

Games in the form of a oriented tree



		Player 2		
		Rock	Scissors	Paper
Player 1	Rock	0; 0	+1; -1	-1; +1
	Scissors	-1; +1	0; 0	+1; -1
	Paper	+1; -1	-1; +1	0; 0

G=<P,S,F>

where:

- P={1, 2,..., m}- a finite set of players.
- S={S_1, S_2, ..., S_m} - the set of actions (strategies) available to players
- F={F_1, F_2, ..., F_m}- many payment functions for each player.

CARTESIAN PRODUCT OF THE SETS STRATEGIES

$$S = \prod_{i=1}^{N} S_i = \{(s_1, s_2, \dots, s_N) | s_1 \in S_1, s_s \in S_2, \dots, s_N \in S_N\}$$

{(STONE, STONE); (STONE, SCISSORS); …;(PAPER, PAPER)}

INTERACTION OF THE PLAYERS IS REPRESENTED AS **MATHEMATICAL OBJECT** WHICH CONTAINS ALL INFORMATION ABOUT THE INVESTIGATED CONFLICT

SOLUTION CAN BE CONSIDERED AS "COMPROMISE" OPTIONS AND "BEST FOR EVERYONE"



Cooperative and non-cooperative games

Cooperative and non-cooperative games

THE GAME IS COOPERATIVE IF PLAYERS CAN UNITE IN GROUPS, TAKING ON SOME OBLIGATIONS TO OTHER PLAYERS AND COORDINATING THEIR ACTIONS.



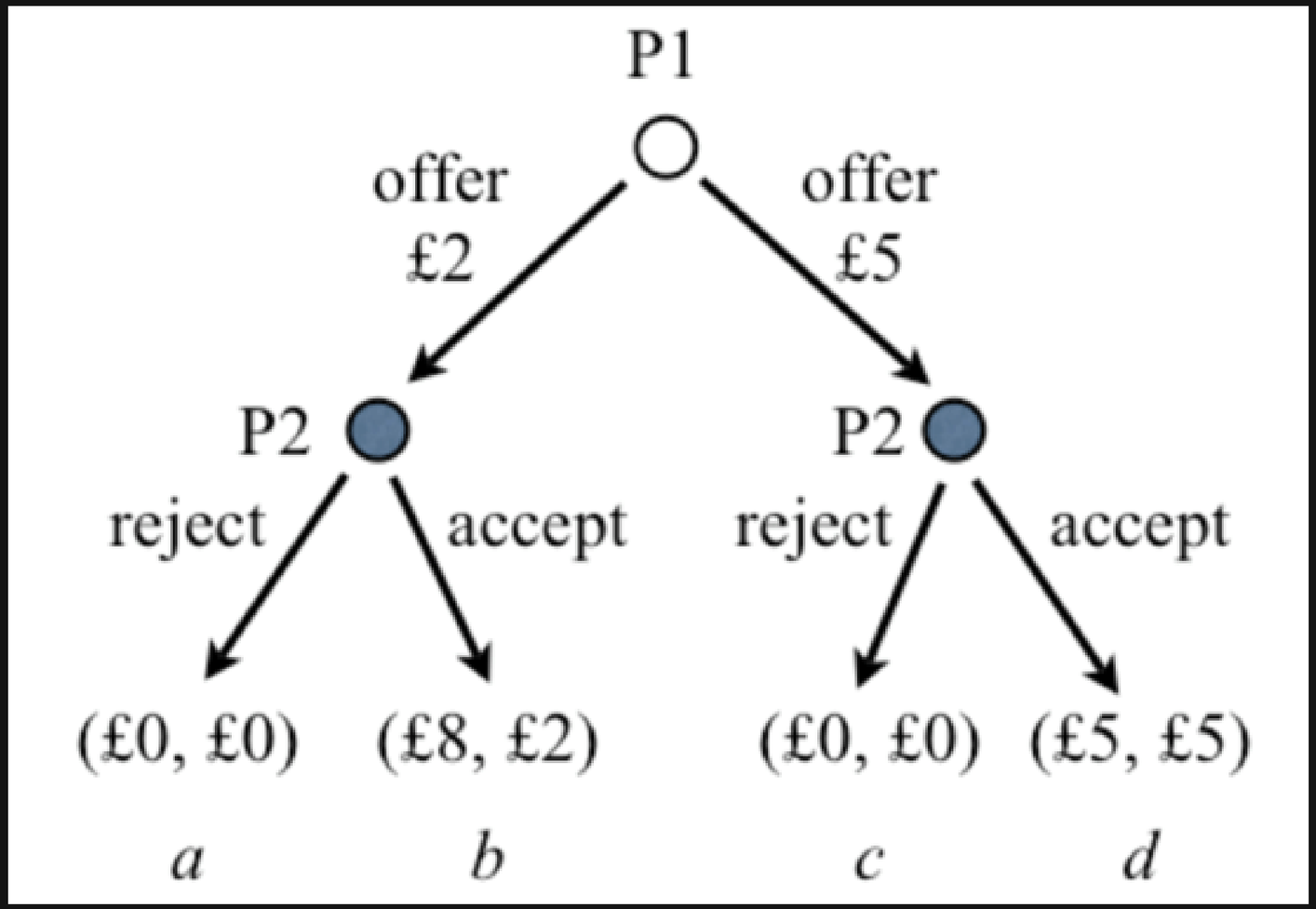
IN NON-COOPERATIVE GAMES EVERYONE IS OBLIGED TO PLAY FOR THEMSELVES. GAMES DESCRIBE SITUATIONS IN GREAT DETAIL AND PRODUCE MORE ACCURATE RESULTS.

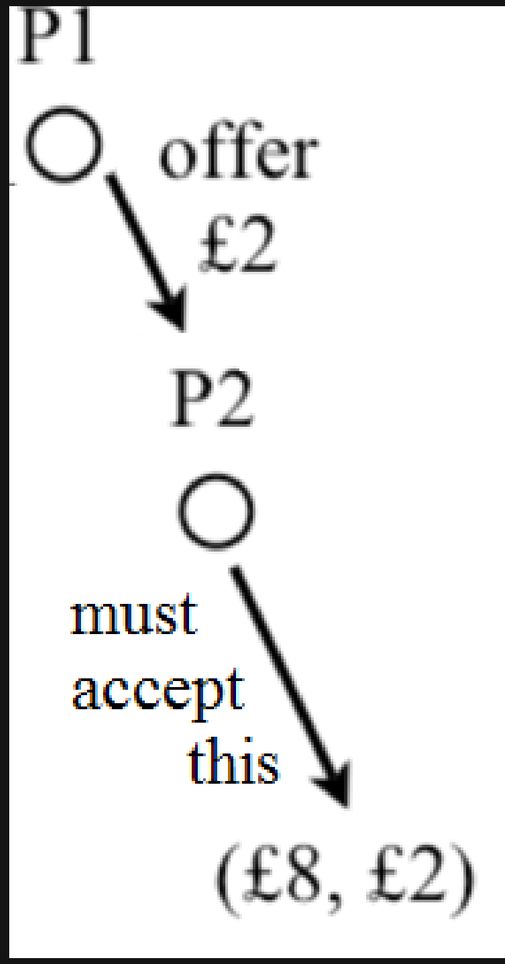
Symmetrical and asymmetrical games

		Agent B	
		Action 1	Action 2
Agent A	Action 1	(R,R)	(S,T)
	Action 2	(T,S)	(P,P)

		Agent B	
		Action 1	Action 2
Agent A	Action 1	(U,W)	(S,T)
	Action 2	(T,S)	(U,W)

Symmetrical and asymmetrical games







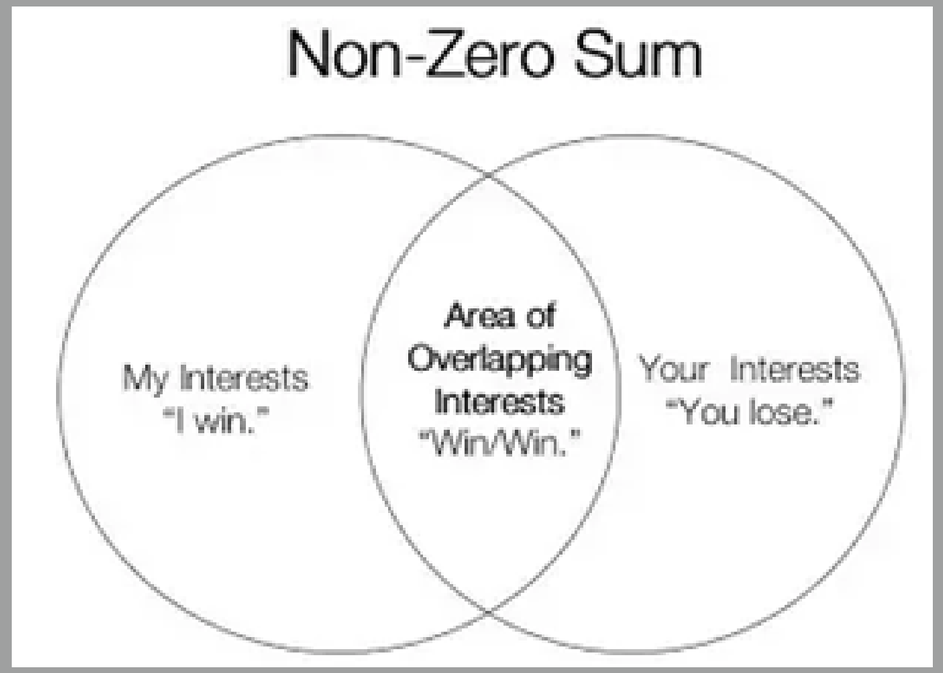
Zero-sum game and Non-Zero Sum Games

Zero-sum game and Non-Zero Sum Games

ZERO-SUM GAMES - THE PLAYERS CANNOT INCREASE OR DECREASE THE AVAILABLE RESOURCES OR THE FUND OF THE GAME.

	A	B
A	−4, 4	5, −5
B	0, 0	−1, 1

Zero-sum game



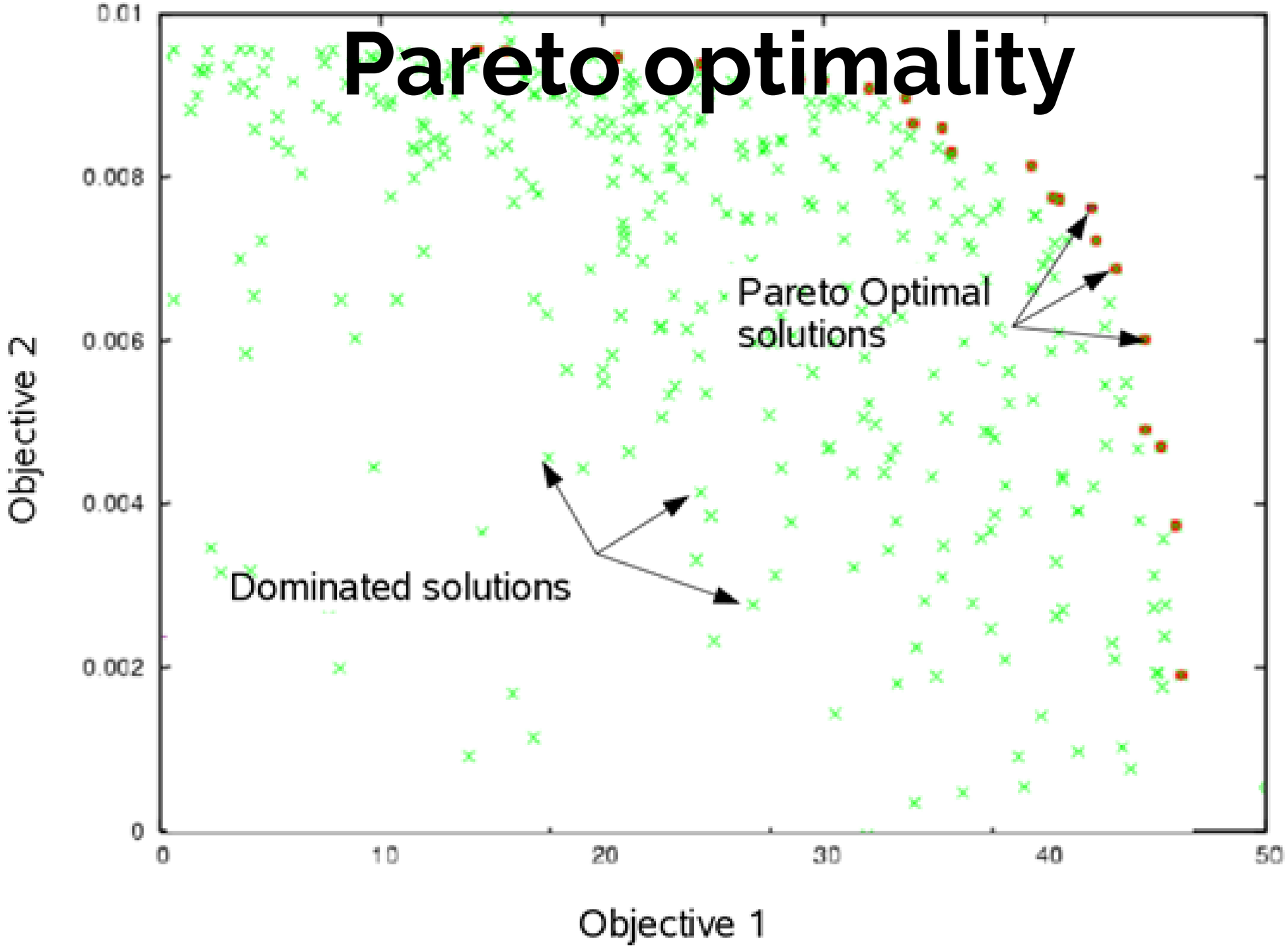
IN NON-ZERO-SUM GAMES, THE GAIN OF ONE PLAYER DOES NOT NECESSARILY MEAN THE LOSS OF ANOTHER, AND VICE VERSA.

Pareto optimality

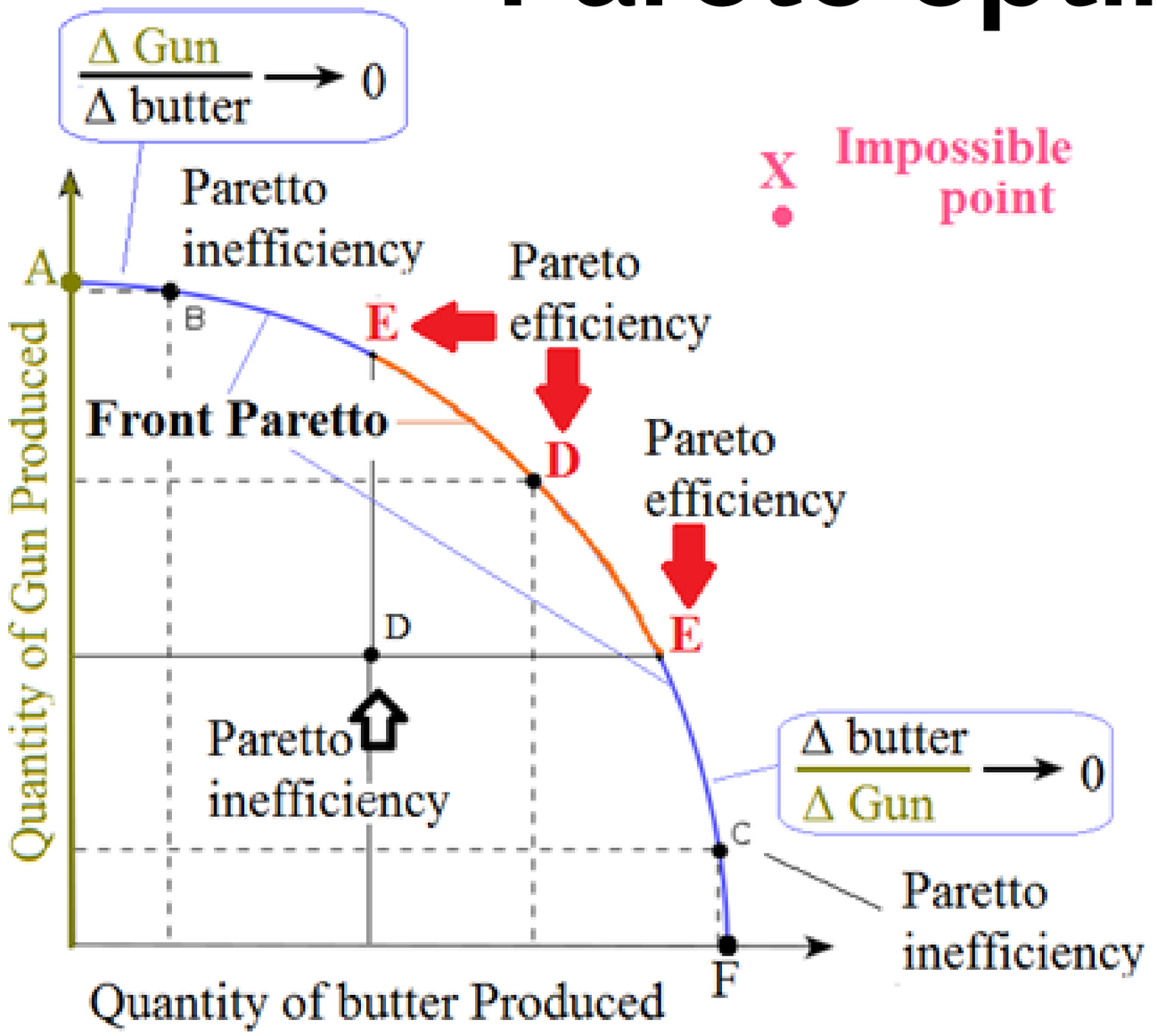
IS A STATE OF A CERTAIN SYSTEM IN WHICH THE VALUE OF EACH PARTICULAR INDICATOR CHARACTERIZING THE SYSTEM CANNOT BE IMPROVED WITHOUT DETERIORATING OTHERS



Pareto optimality



Pareto optimality



Points "B" and "C" are considered Pareto ineffective, because:

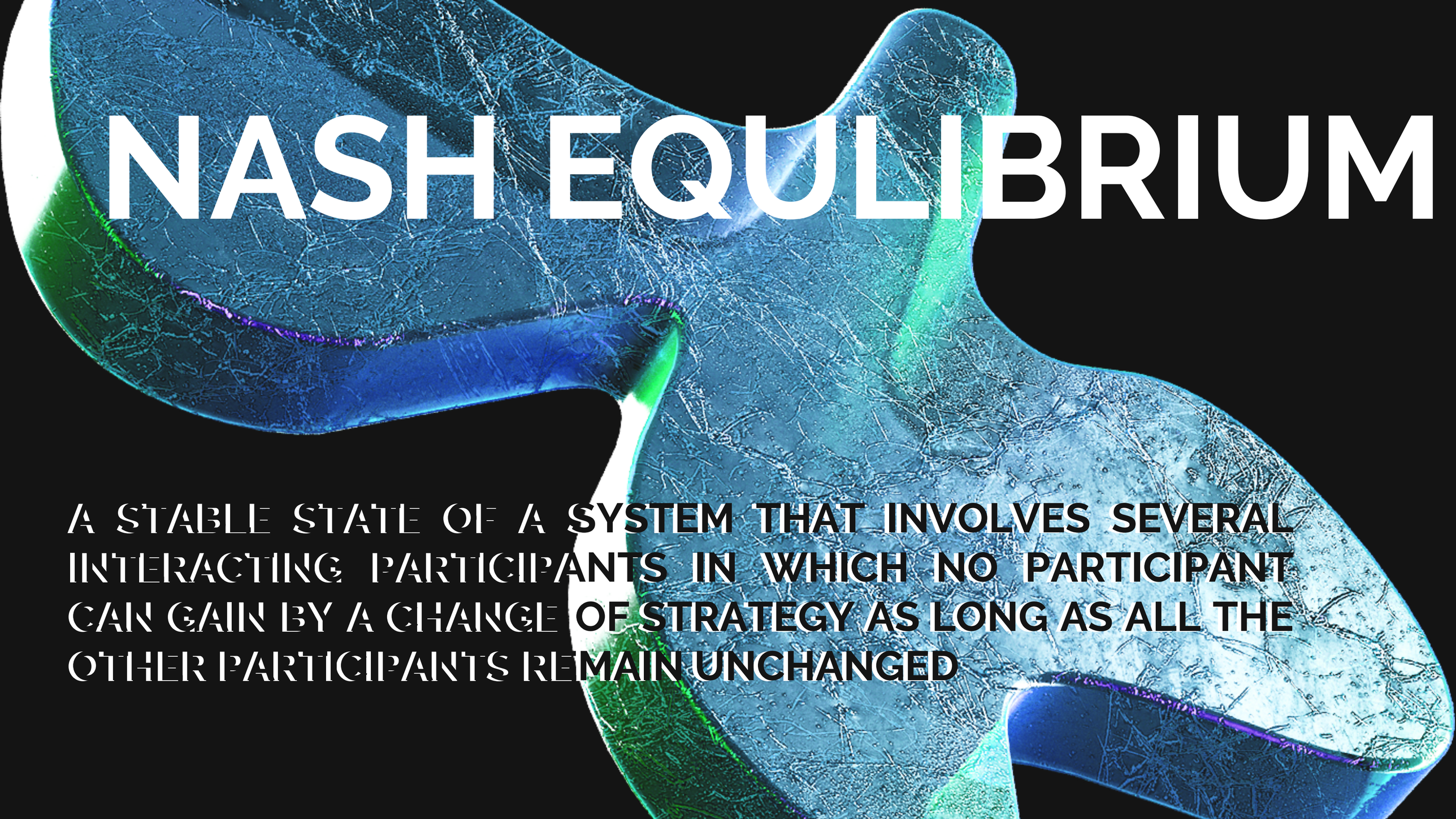
1) In section A-E an increase in guns production leads to a slight decrease in butter production, which can be neglected:

ΔGun / Δbutter ->0

2) In section E-F an increase in butter production leads to a slight decrease inguns production, which can be neglected:

Δbutter / ΔGun ->0

NASH EQULIBRIUM



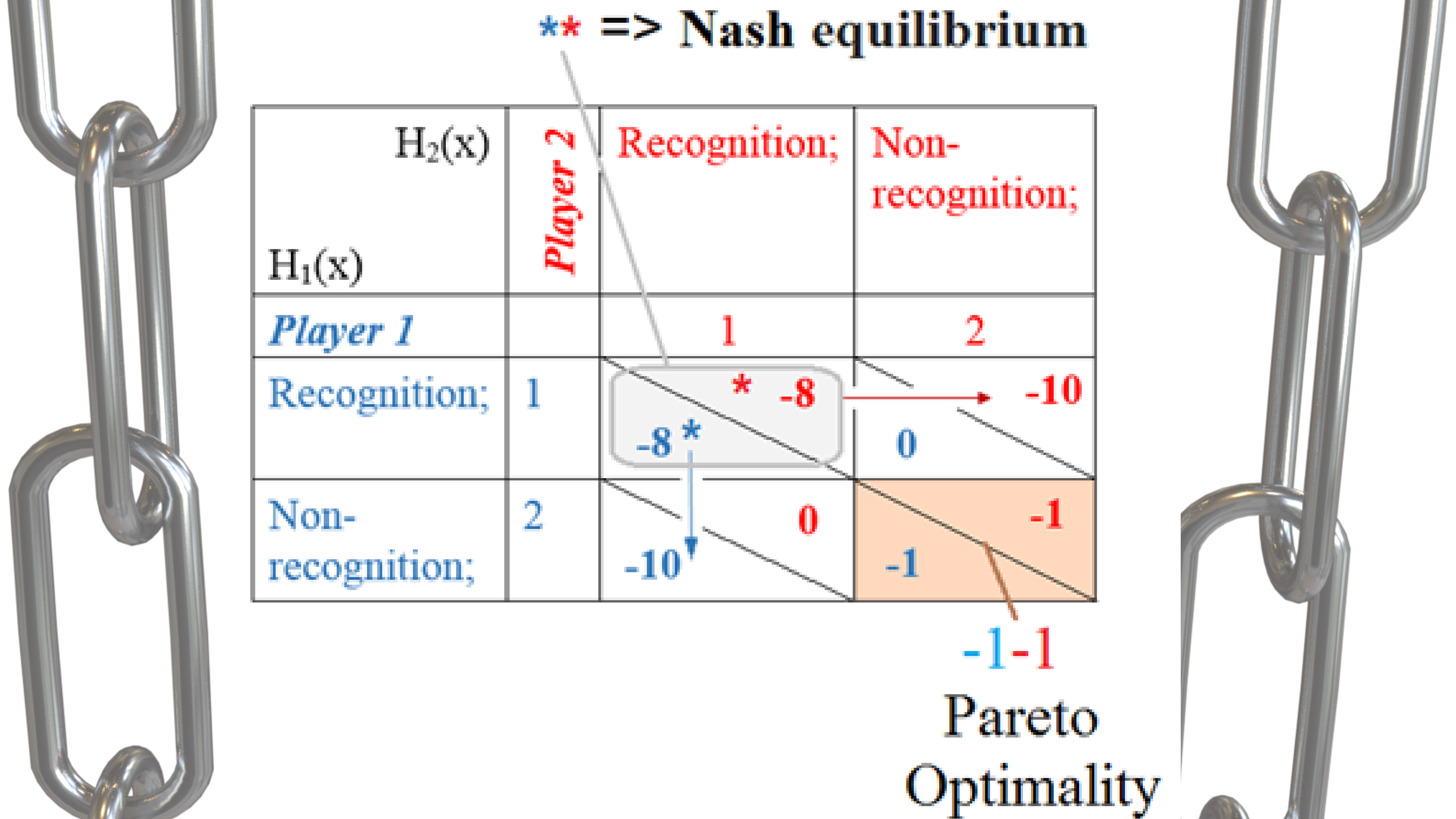
A STABLE STATE OF A SYSTEM THAT INVOLVES SEVERAL INTERACTING PARTICIPANTS IN WHICH NO PARTICIPANT CAN GAIN BY A CHANGE OF STRATEGY AS LONG AS ALL THE OTHER PARTICIPANTS REMAIN UNCHANGED

The Prisoner's Dilemma

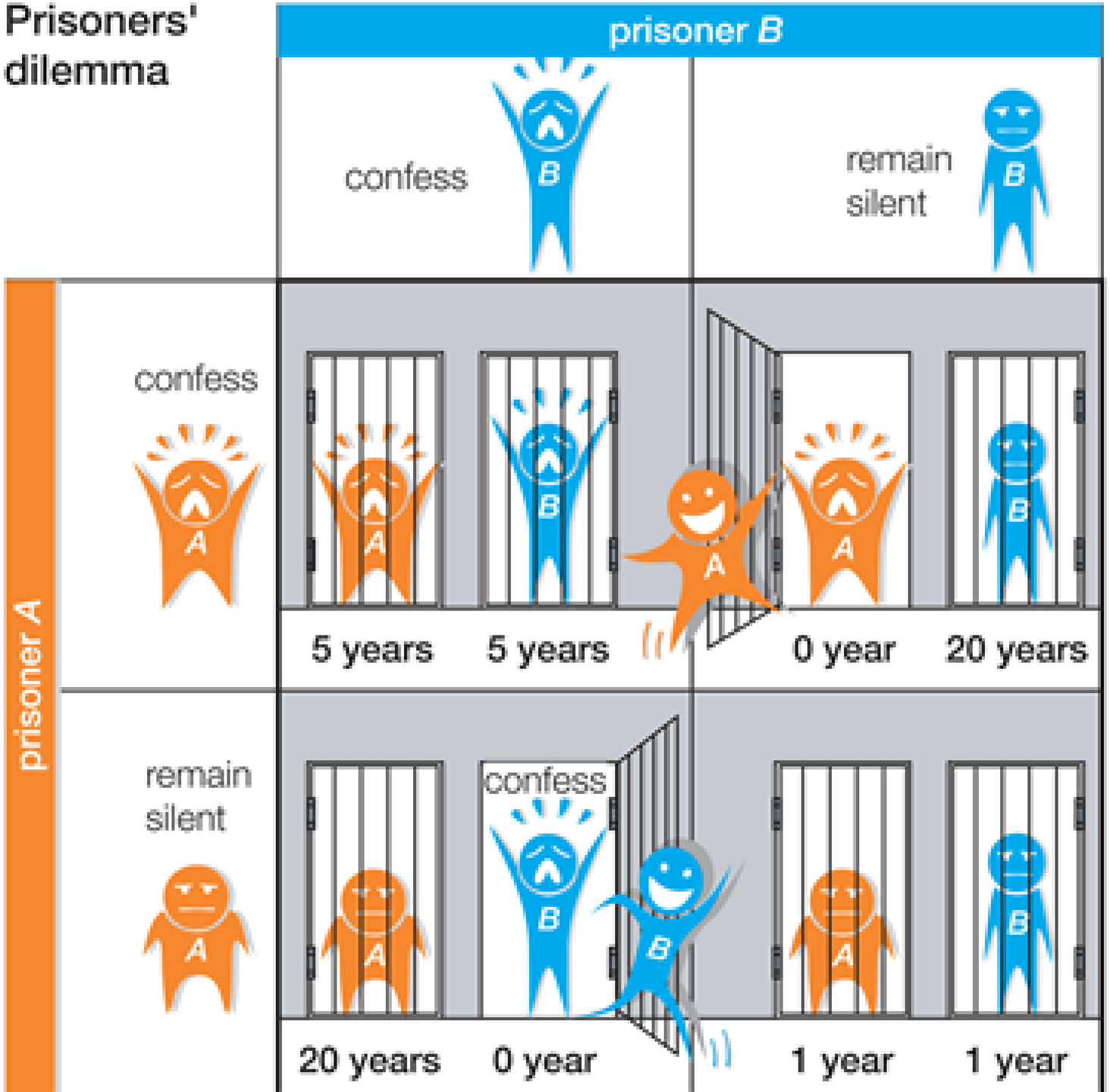
$H_2(x)$ $H_1(x)$	*Player 2*	Recognition;	Non-recognition;
Player 1		1	2
Recognition;	1	**-8**	**0**
Non-recognition;	2	**-10**	**-1**

The Prisoner's Dilemma

$H_2(x)$ $H_1(x)$	*Player 2*	Recognition;	Non-recognition;
Player 1		1	2
Recognition;	1	**-8**	**-10**
Non-recognition;	2	**0**	**-1**


** => Nash equilibrium
H2(x)
H1(x)
Player 2
Recognition;
Non-recognition;
Player 1
1
2
Recognition;
1
* -8
-8 *
-10
0
Non-recognition;
2
0
-10
-1
-1
-1-1
Pareto Optimality

Prisoners' dilemma



The legacy dilemma



The legacy dilemma

$H_2(x)$ / $H_1(x)$	*Heir 2*	Distrust;	Trust;
Heir 1		1	2
Distrust;	1	**33%**	**100%**
Trust;	2	**0%**	**50%**

The legacy dilemma

$H_2(x)$ / $H_1(x)$	*Heir 2*	Distrust;	Trust;
Heir 1		1	2
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The legacy dilemma

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Heir 1		1	2
Distrust;	1	*33%	0%
		*33%	100%
Trust;	2	100%	50%
		0%	50%

The Cola dilemma

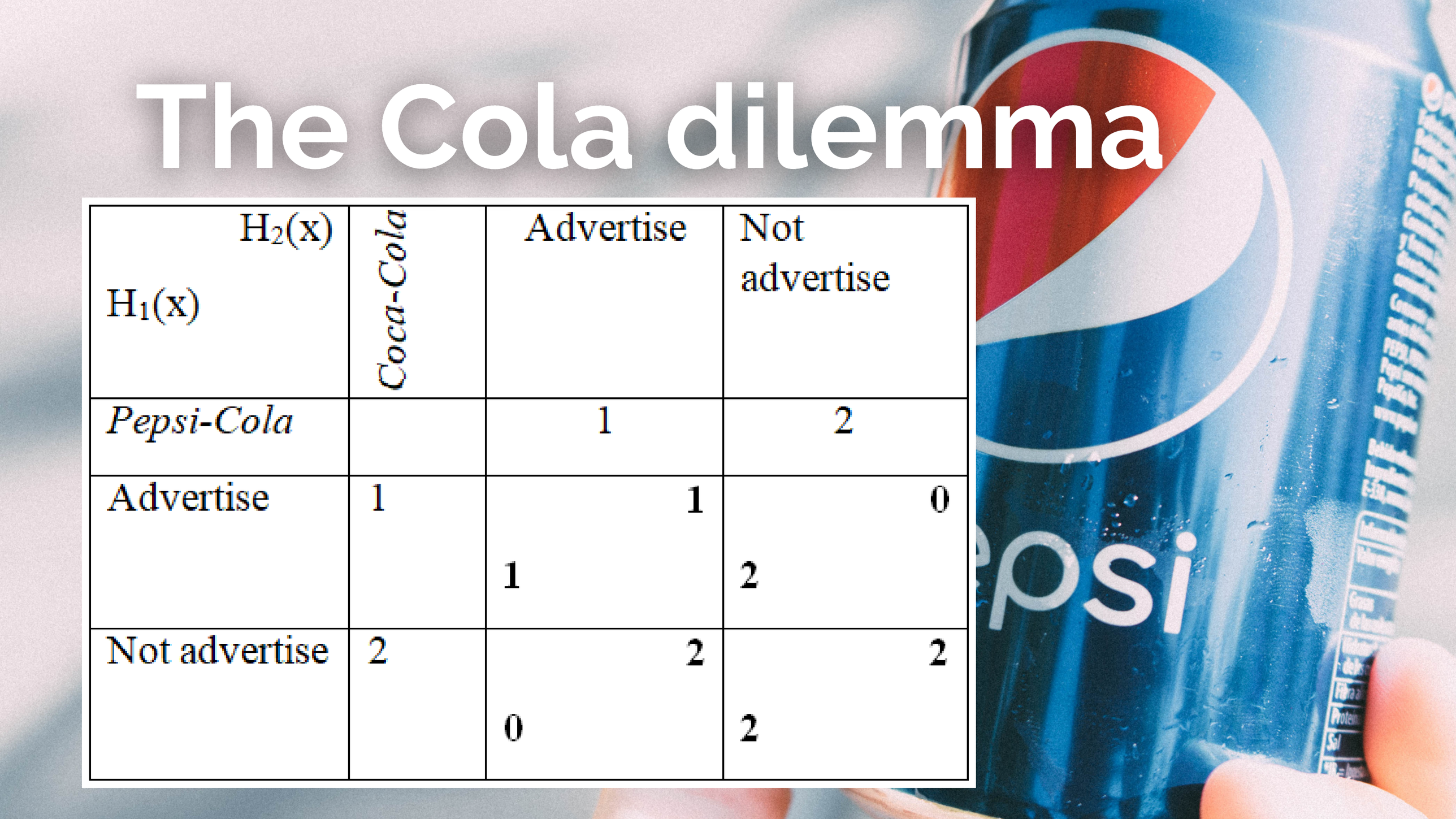


The Cola dilemma

$H_2(x)$ / $H_1(x)$	*Coca-Cola*	Advertise	Not advertise
Pepsi-Cola		1	2
Advertise	1	**1**	**2**
Not advertise	2	**0**	**2**

The Cola dilemma

$H_2(x)$ / $H_1(x)$	*Coca-Cola*	Advertise	Not advertise
Pepsi-Cola		1	2
Advertise	1	**1** **1**	**0** **2**
Not advertise	2	**2** **0**	**2** **2**



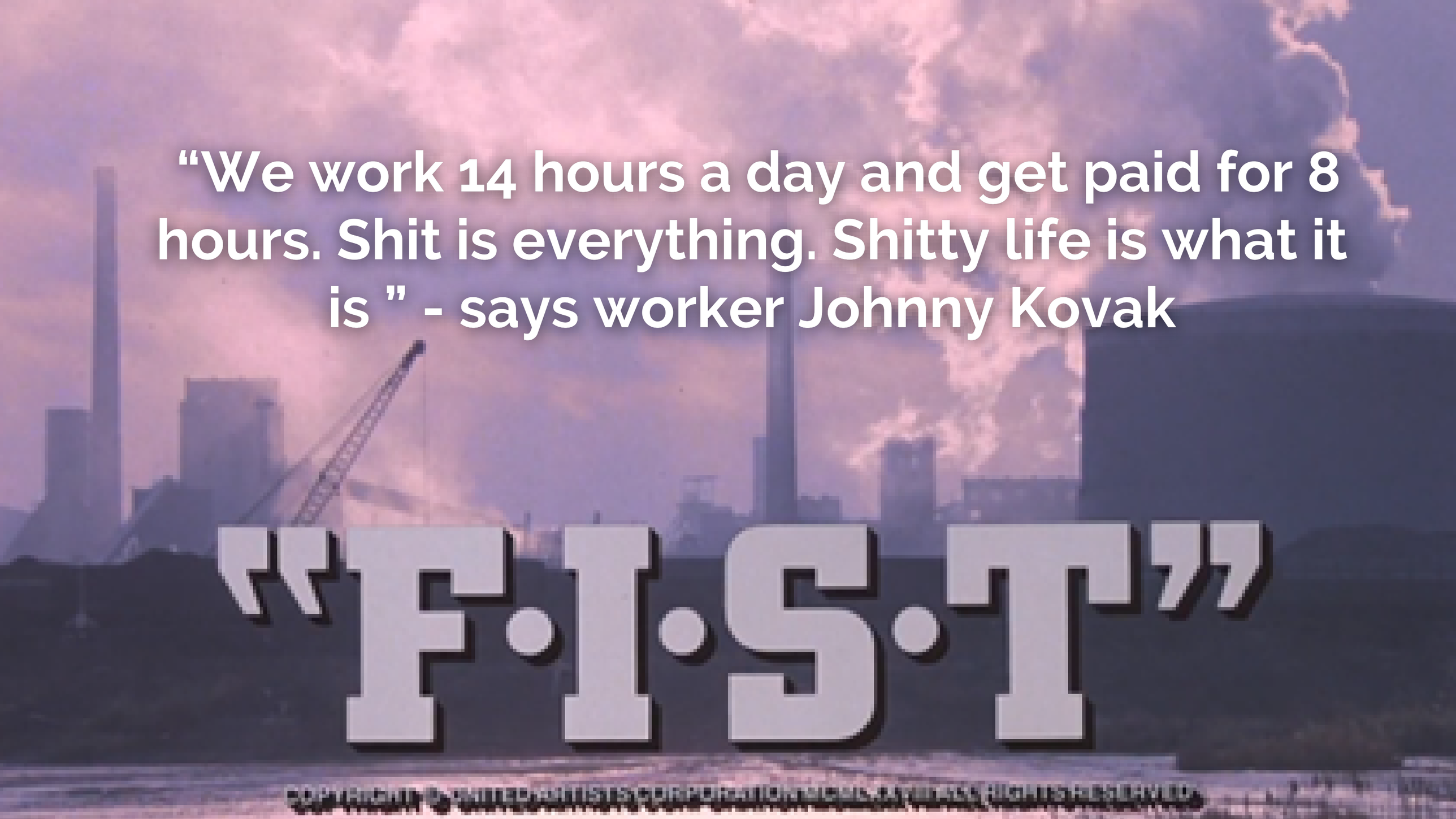
The Cola dilemma

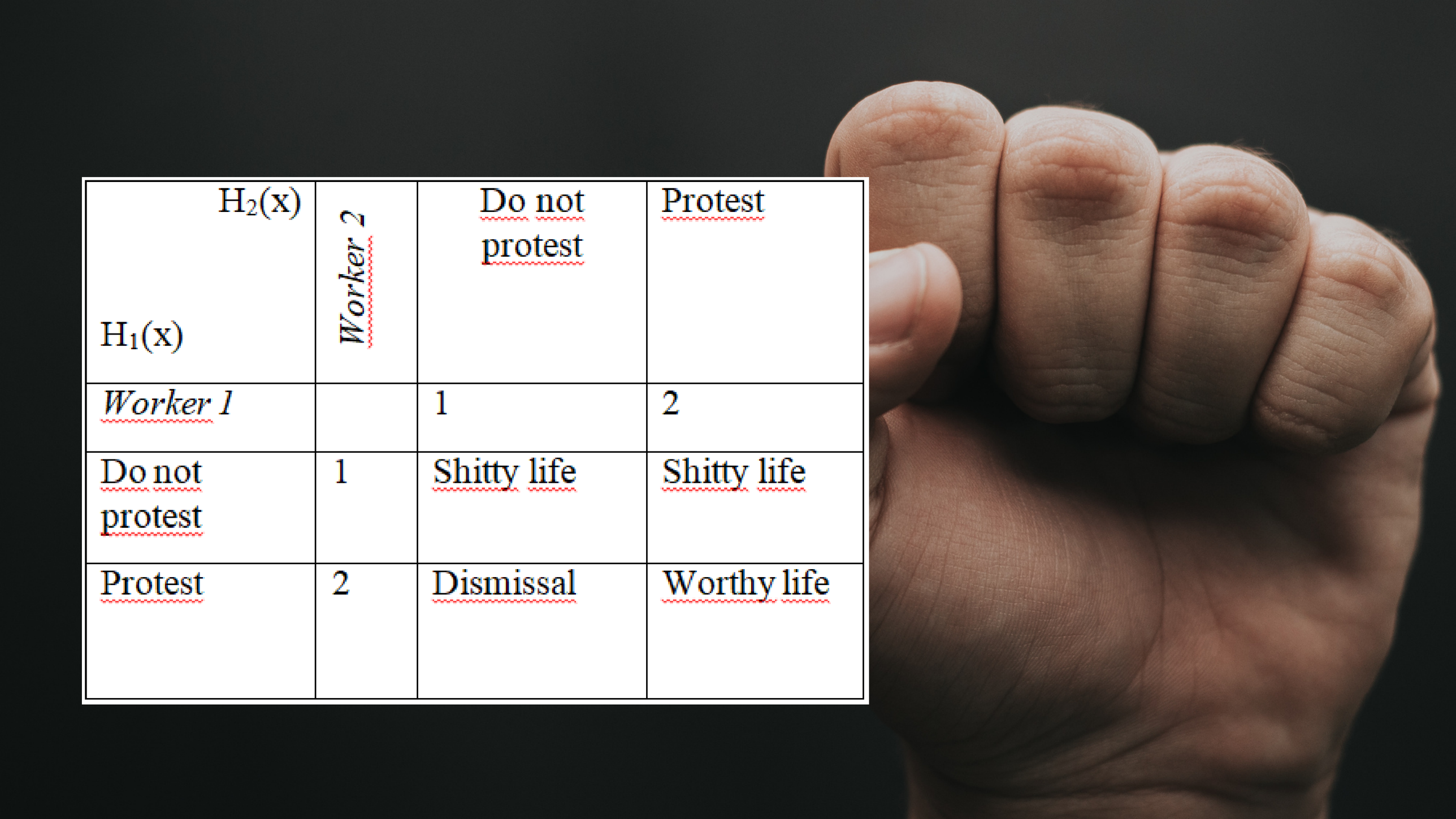
$H_2(x)$ / $H_1(x)$	*Coca-Cola*	Advertise	Not advertise
Pepsi-Cola		1	2
Advertise	1	**1** **1**	**0** **2**
Not advertise	2	**2** **0**	**2** **2**



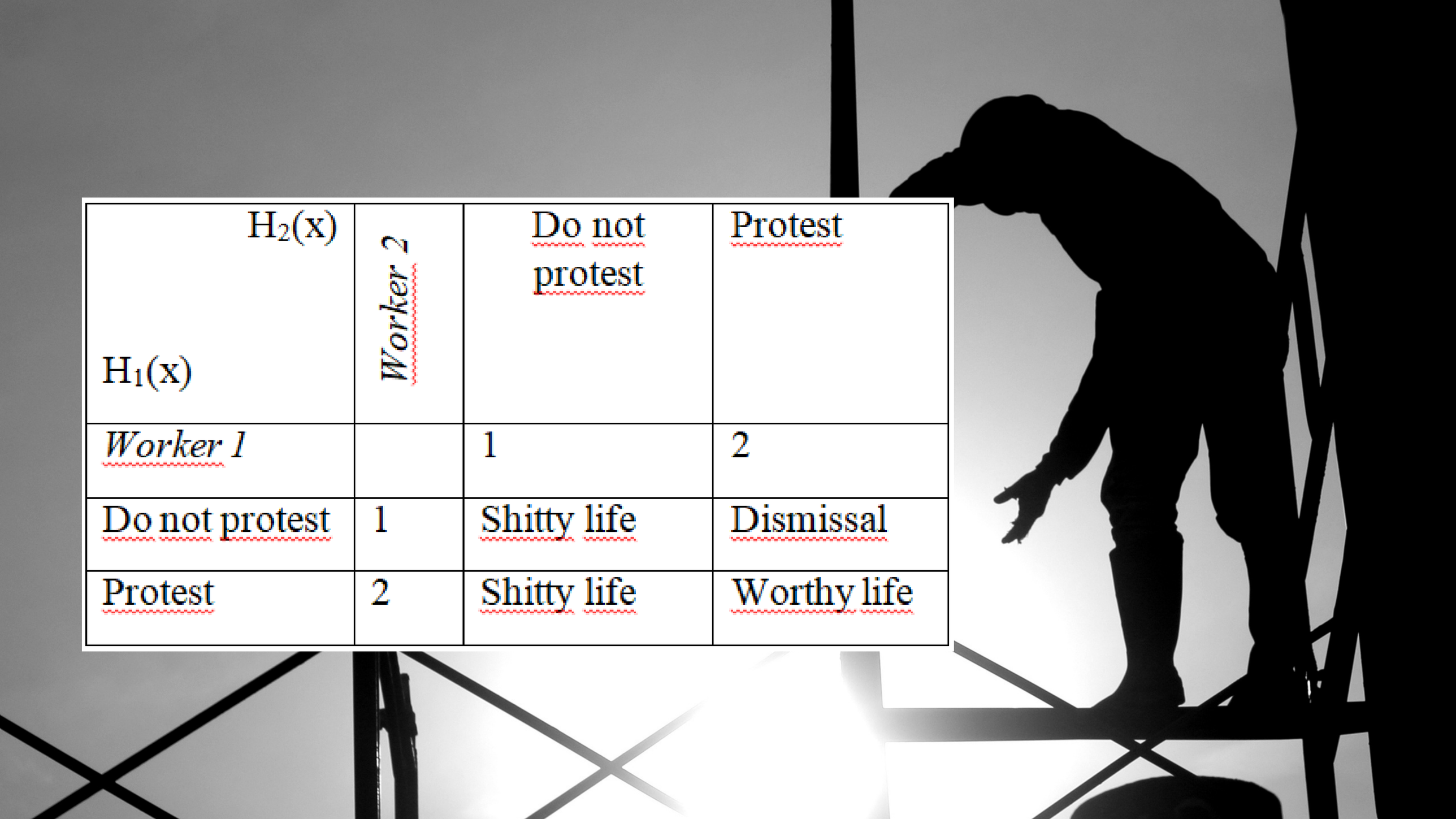
Nash Equilibrium on the example of the

"F.I.S.T"

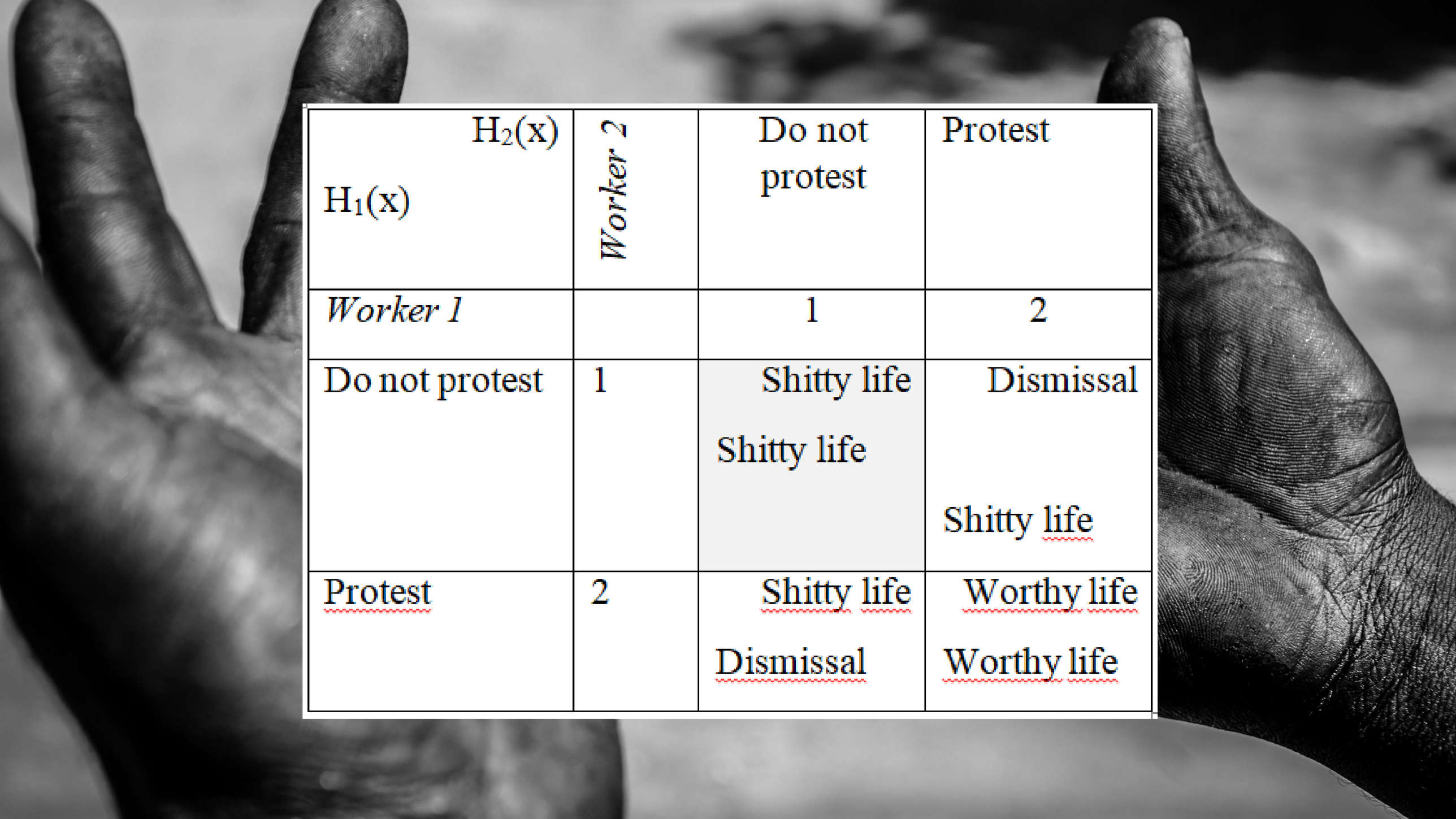

“We work 14 hours a day and get paid for 8 hours. Shit is everything. Shitty life is what it is ” - says worker Johnny Kovak
“F·I·S·T”



$H_2(x)$ $H_1(x)$	*Worker 2*	Do not protest	Protest
Worker 1		1	2
Do not protest	1	Shitty life	Shitty life
Protest	2	Dismissal	Worthy life



$H_2(x)$ $H_1(x)$	*Worker 2*	Do not protest	Protest
Worker 1		1	2
Do not protest	1	Shitty life	Dismissal
Protest	2	Shitty life	Worthy life



$H_2(x)$ $H_1(x)$	*Worker 2*	Do not protest	Protest
Worker 1		1	2
Do not protest	1	Shitty life Shitty life	Dismissal Shitty life
Protest	2	Shitty life Dismissal	Worthy life Worthy life

$H_2(x)$ / $H_1(x)$	*Worker 2*	Do not protest	Protest
Worker 1		1	2
Do not protest	1	Shitty life	Shitty life
Protest	2	Dismissal	Worthy life

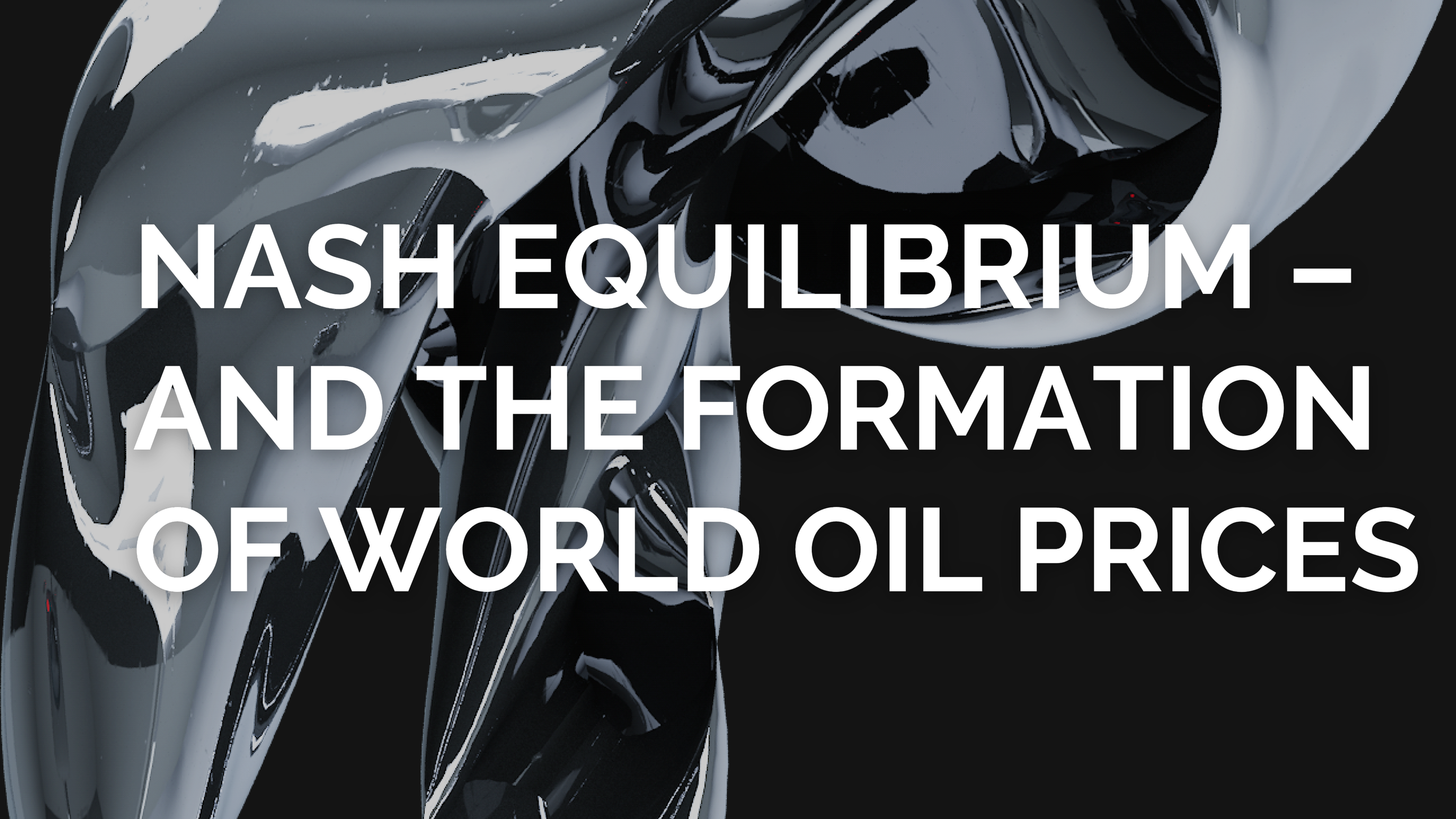
$$H1(x1^*, x2^*) >= H1(x1, x2^*)$$

$H_2(x)$ / $H_1(x)$	*Worker 2*	Do not protest	Protest
Worker 1		1	2
Do not protest	1	Shitty life	Dismissal
Protest	2	Shitty life	Worthy life

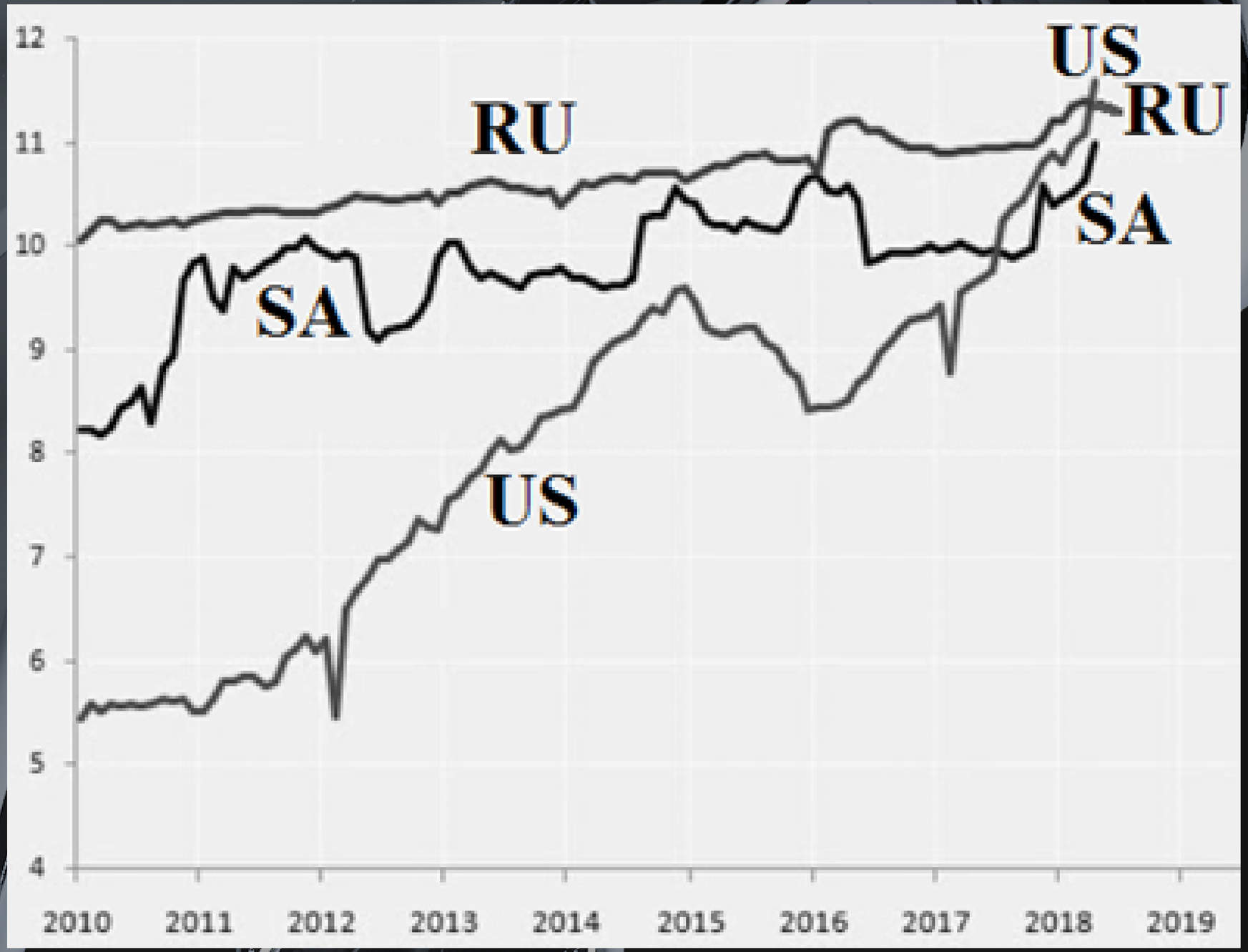
$$H1(x2^*, x1^*) >= H1(x2, x1^*)$$

Classic Nash equilibrium

$$H_i(x_i^*, x^*_{-i}) \geqslant H_i(x_i, x^*_{-i})$$



NASH EQUILIBRIUM – AND THE FORMATION OF WORLD OIL PRICES


12
11
10
9
8
7
6
5
4
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
RU
SA
US
US
RU
SA

	Barrel	1.	2.
		$8 \cdot 10^6$ / day	$10 \cdot 10^6$ / day
1.	$8 \cdot 10^6$	$800 millions per day $100 $800 millions per day	$850 millions per day $85 $680
2.	$10 \cdot 10^6$ / day	$680 millions per day $85 $850 millions per day	$700 millions per day $70 $700 millions per day

ONE OF THEM WILL BE DISHONEST:

a) More oil on the market ;
b) The price will fall;
c) The party that increased oil production will still receive more profit, though at the expense of future generations;
d) The party that remains faithful to its obligations will remain at a loss;
e) The injured party will try to compensate for the loss by increasing oil production;
f) Since there is even more oil on the market, the price for it falls;
g) The profit on both sides is reduced to a value


Oil price hits 18-year low
Brent crude, US dollars per barrel
$150
$125
$100
$75
$50
$25
$0
2000
2004
2008
2012
2016
2020
2021


Thank you!
Any questions?