Classical Game Theory
and
Behavioral Game Theory

نظریه بازیهای کلاسیک و بازیهای رفتاری

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۳ شهریور ۱۴۰۵

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Expected Value, Expected Utility, Prospect Theory

ارزش مورد انتظار، مطلوبیت انتظاری و نظریه چشم انداز

Part II

Classical Game Theory

Focal Point, Nash Equilibrium ,Pareto Efficiency, Rawls Justice, Amartya Sen Capability Approach

نقطه کانونی، تعادل نش ، کارایی پاره تو، عدالت رالز، رویکرد قابلیت آمارتیاسن

Behavioral Game Theory

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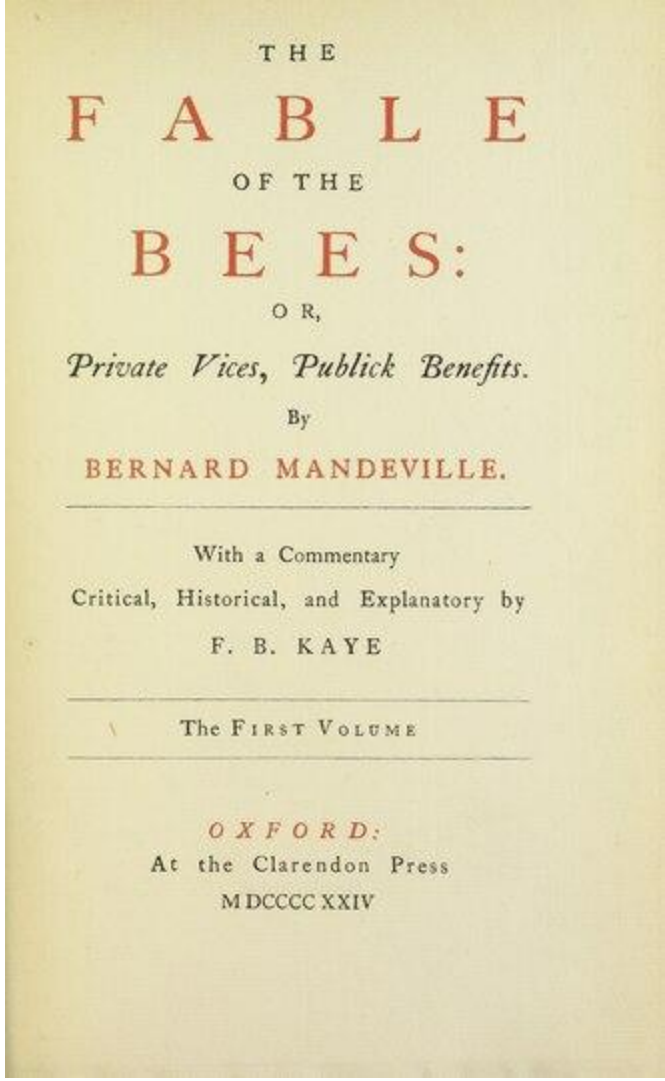
Industrial Policy Case Studies

مطالعات موردی سیاست صنعتی (سبزشدن بنگاه ها)

افسانه زنبوران


THE
FABLE
OF THE
BEES:
OR,
Private Vices, Publick Benefits.
By
BERNARD MANDEVILLE.

With a Commentary
Critical, Historical, and Explanatory by
F. B. KAYE

The First Volume

OXFORD:
At the Clarendon Press
MDCCCC XXIV

پیام ماندویل: پس ای زنبورها دیگر ناله نکنید! احمقانه است که بخواهید هم از نعمت‌های یک امپراتوری بزرگ، ثروتمند و قدرتمند لذت ببرید و همزمان در یک روستای کوچک با فضیلت‌های ساده و پاکدامنانه زندگی کنید. بهشتِ طلایی (رفاه) و بهشتِ اخلاقی (فضیلت) در این دنیا با هم جمع نمی‌شوند.

Expected value vs. Expected Utility

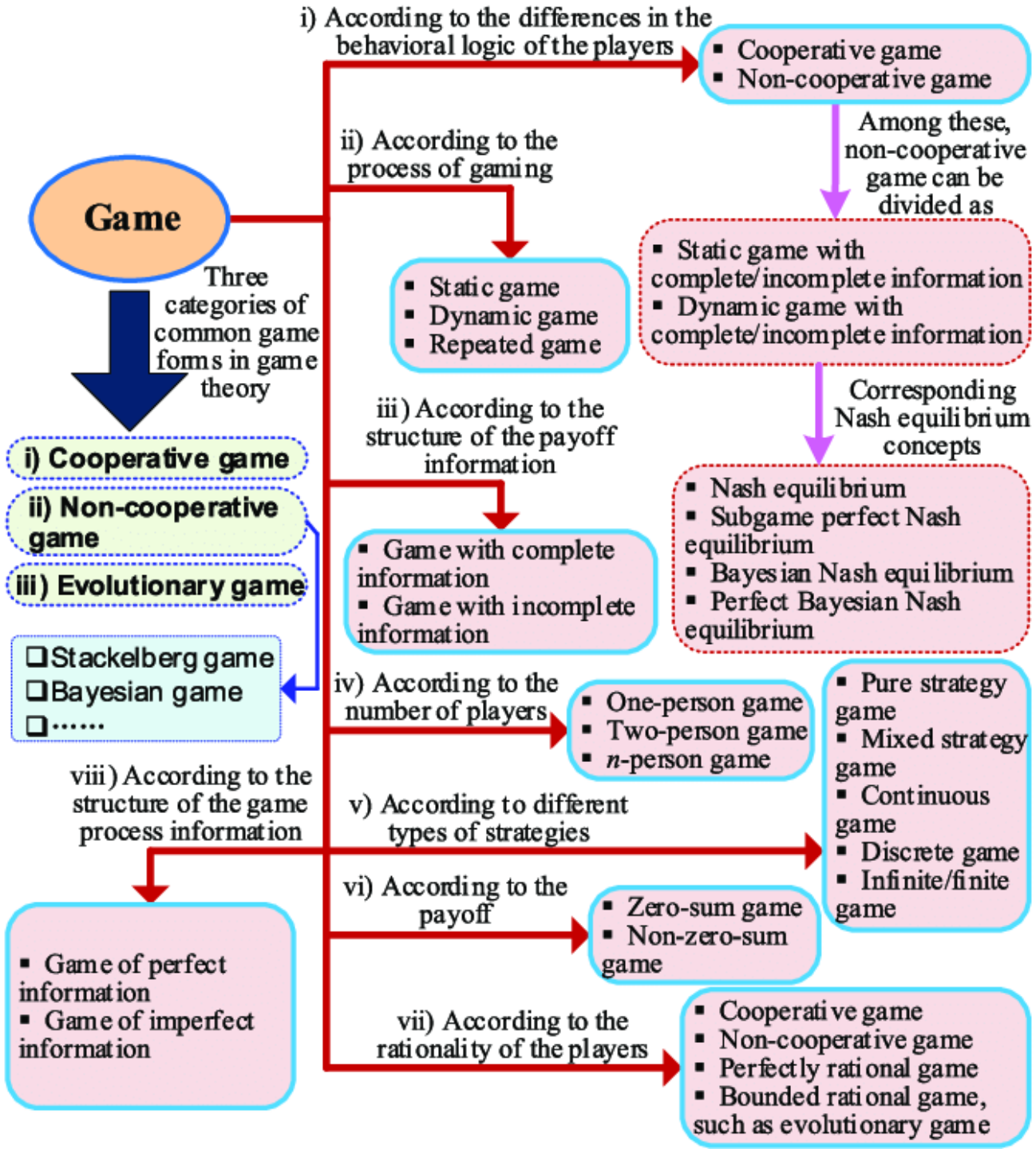
Expected value theory says you should always choose the option with the HIGHEST EXPECTED VALUE.

A: $1 million for sure
B :50% chance of $3 million
EV says you should prefer B to A. Many people prefer A to B.
Why do people prefer A to B , in contrast to the advice given by EV theory?

A. 99% chance of $100
B. $1 for sure

A. 95% chance of $1 million
B. 50% chance of $3 million

In this situation, most people would prefer A. But BOTH A and B are gambles. $3 million is not really three times as desirable a consequence as $1 million. This is the answer given by expected utility theory.

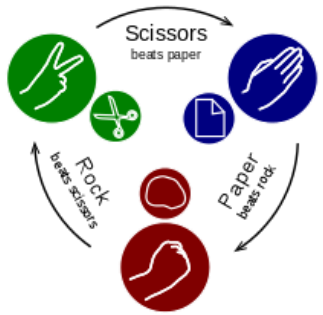

Game
Three categories of common game forms in game theory
i) Cooperative game
ii) Non-cooperative game
iii) Evolutionary game
Stackelberg game
Bayesian game
……
i) According to the differences in the behavioral logic of the players
Cooperative game
Non-cooperative game
Among these, non-cooperative game can be divided as
Static game with complete/incomplete information
Dynamic game with complete/incomplete information
ii) According to the process of gaming
Static game
Dynamic game
Repeated game
Corresponding Nash equilibrium concepts
Nash equilibrium
Subgame perfect Nash equilibrium
Bayesian Nash equilibrium
Perfect Bayesian Nash equilibrium
iii) According to the structure of the payoff information
Game with complete information
Game with incomplete information
iv) According to the number of players
One-person game
Two-person game
n-person game
v) According to different types of strategies
Pure strategy game
Mixed strategy game
Continuous game
Discrete game
Infinite/finite game
vi) According to the payoff
Zero-sum game
Non-zero-sum game
vii) According to the rationality of the players
Cooperative game
Non-cooperative game
Perfectly rational game
Bounded rational game, such as evolutionary game
viii) According to the structure of the game process information
Game of perfect information
Game of imperfect information

Game Theory classification

- **Simultaneous Move Games and Sequential Move Games**
- A simultaneous-move (static) game is a game in which both players must choose their strategies at the same time. No player knows for sure what the other player's course of action would be. Examples of simultaneous-move games include:

Two firms in an oligopoly deciding about their output level (in Cournot model) or price level (in Bertrand model) or two prisoners deciding about whether to confess or not in the prisoners' dilemma, football penalty kicks

- On the contrary, a sequential (dynamic) game is a game where one player chooses their action before the others choose theirs. However, in sequential games, the players do not have a deep knowledge about the strategies of other players.



Game Theory classification

- **Cooperative ,Non cooperative**

Non-cooperative games refer to the games in which the players decide on their own strategy to maximize their profit. The best example for non cooperative game is Prisoner dilemma.

Cooperative games are the one in which players are convinced to adopt a particular strategy through negotiations and agreements between players.

- **Fixed rules or Not fixed rules**
  - Card game , chess
  - Business , politics, real life

Game Theory classification

- **Zero sum, non-zero-sum game**
- Zero-sum game is a mathematical representation of a situation in which each participant's gain or loss of utility is exactly balanced by the losses or gains of the utility of the other participants. Thus, cutting a cake, where taking a larger piece reduces the amount of cake available for others as much as it increases the amount available for that taker, is a zero-sum game if all participants value each unit of cake equally (see marginal utility).
- In contrast, non-zero-sum describes a situation in which the interacting parties' aggregate gains and losses can be less than or more than zero.

Game Theory classification

- **Perfect information and imperfect information**

Perfect information refers to the fact that each player has the same information that would be available at the end of the game like chess game or tick-tack-toe.

Tic tac toe

In imperfect information players have private information. A good example of imperfect information games is a card game where each player's card are hidden from the rest of the players.

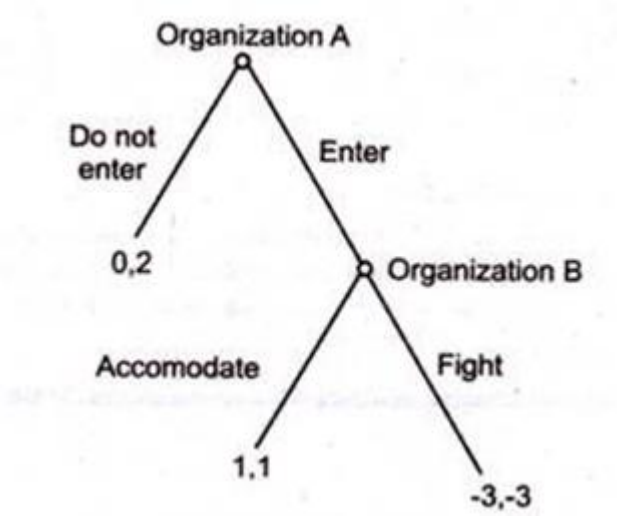
- **One shot game , repeated game**
  - One shot game is a game that is played only once.
  - Repeated games – a game played more than once
    - Tit for tat strategy: if you defect, I defect in the next round
    - Grim trigger strategy: if you defect , I will defect in all future round

Game Theory classification

- **Normal Form and Extensive Form Games**

Normal form games refer to the description of game in the form of matrix. In other words, when the payoff and strategies of a game are represented in a tabular form, it is termed as normal form games.

On the other hand, extensive form games are the one in which the description of game is done in the form of a decision tree.



Game Theory

- Game theory is a field of Mathematics, analyzing strategically inter-dependent situations in which the outcome of your actions depends also on the actions of others.

The birth of game theory invented by von Neumann and Morgenstern (1944):
"We need essentially new mathematical theory to solve variety of problems in social sciences."

- Any social problem can be formalized as a "game," consisting of three elements:

Players: i=1,2,…,N. a rational agents who participated in game

And try to maximize their payoff.

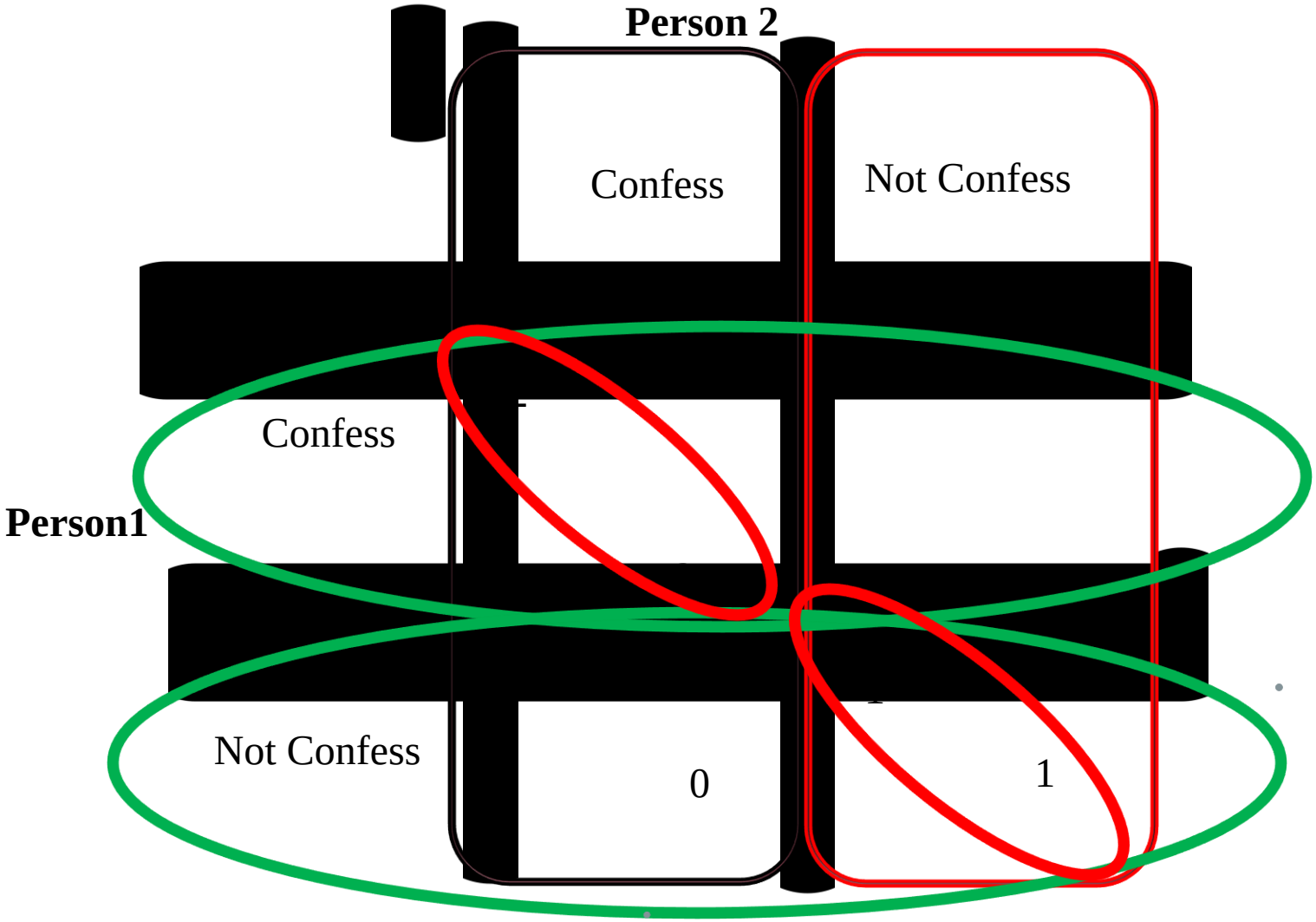
- i's Action: An action which players can choose from a set of possible action in every conceivable situation.
- i's Payoff: the utility that a player receives depending on the strategy profile.

Common knowledge

Some piece of information X

- Knowledge : I know X
- Mutual knowledge : Each of us know the X
- Common knowledge : Each of us knows that each of us know X ,…
- The rules of game is common knowledge (Players, strategies, payoffs ,timing, information,..) are common knowledge.

Prisoners Dilemma



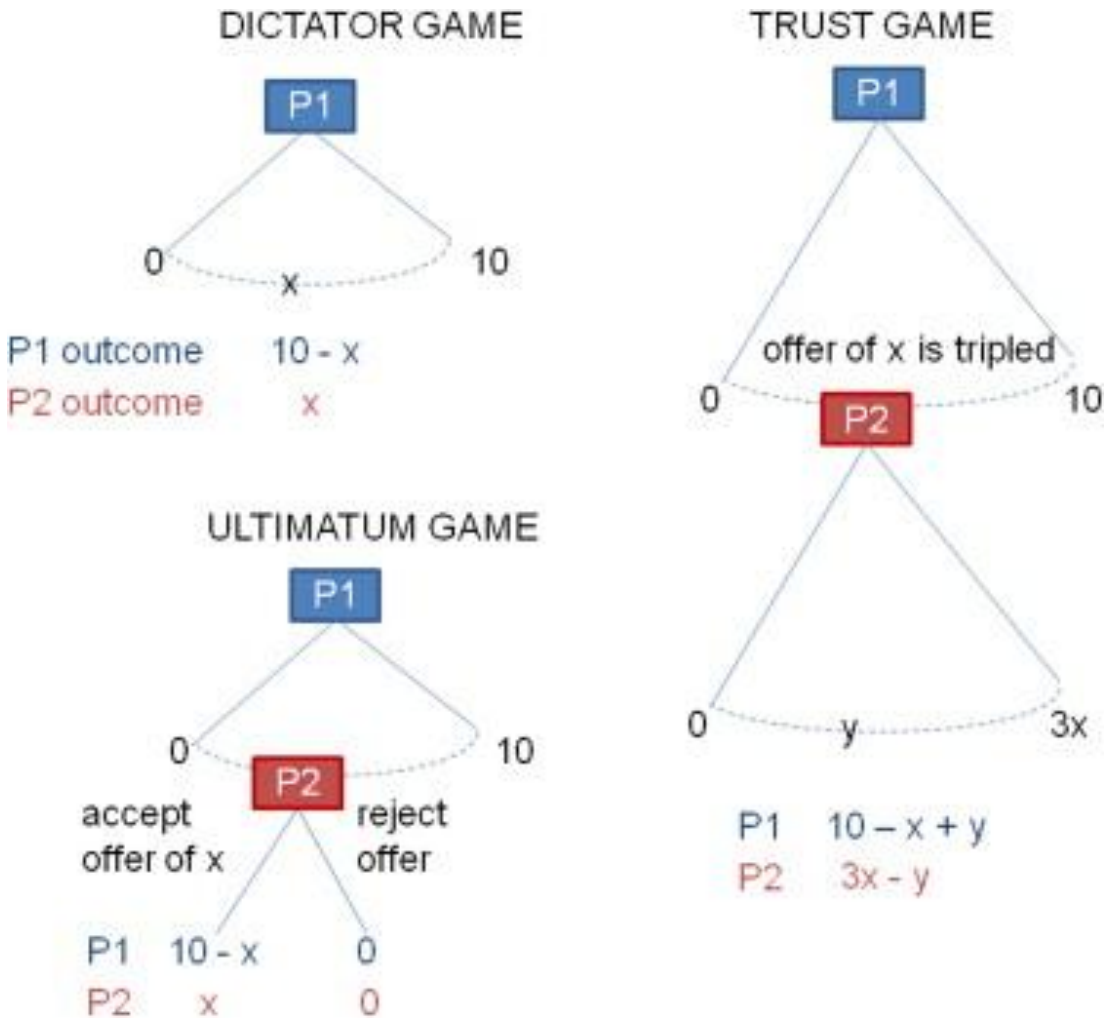
Nash Equilibrium

- $a=(a_1,a_2,\ldots..a_n)$ action profile
- $a^*=(a_1^*, a_2^*,\ldots a_n^*)$ Specific action
- $U_1(a^*)= U_1(a_1^*, a_2^*,\ldots a_n^*) \geq U_1(a_1, a_2^*,\ldots a_n^*)$

Utility of player get with playing a_1^* when everybody else play $a_2^*,\ldots a_n^*$ is bigger than when he play other strategy like a_1

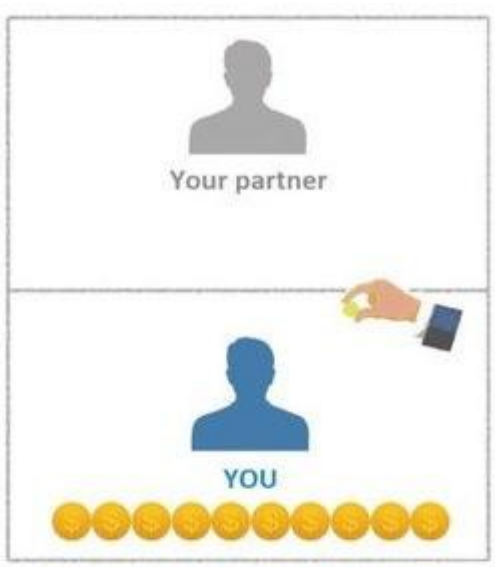
- $U_2(a^*)= U_2(a_1^*, a_2^*,\ldots a_n^*) \geq U_2(a_1^*, a_2,\ldots a_n^*)$

Behavioral Games (Social Preference Games)
بازیهای رفتاری

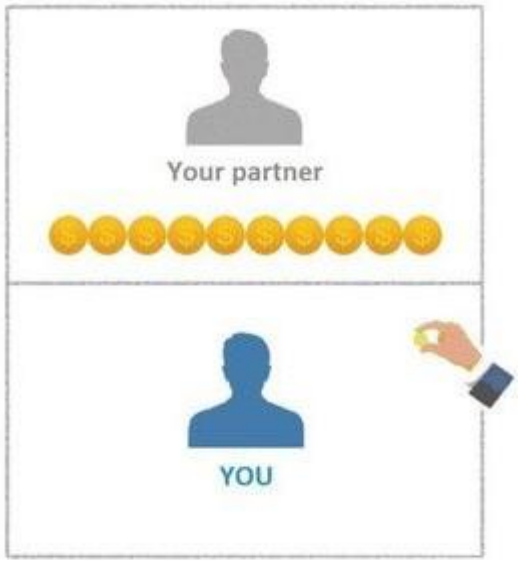


بازی دیکتاتور

A dictator (proposer) decides on the splitting (anonymously)given endowment (pie) between self and another party (receiver).



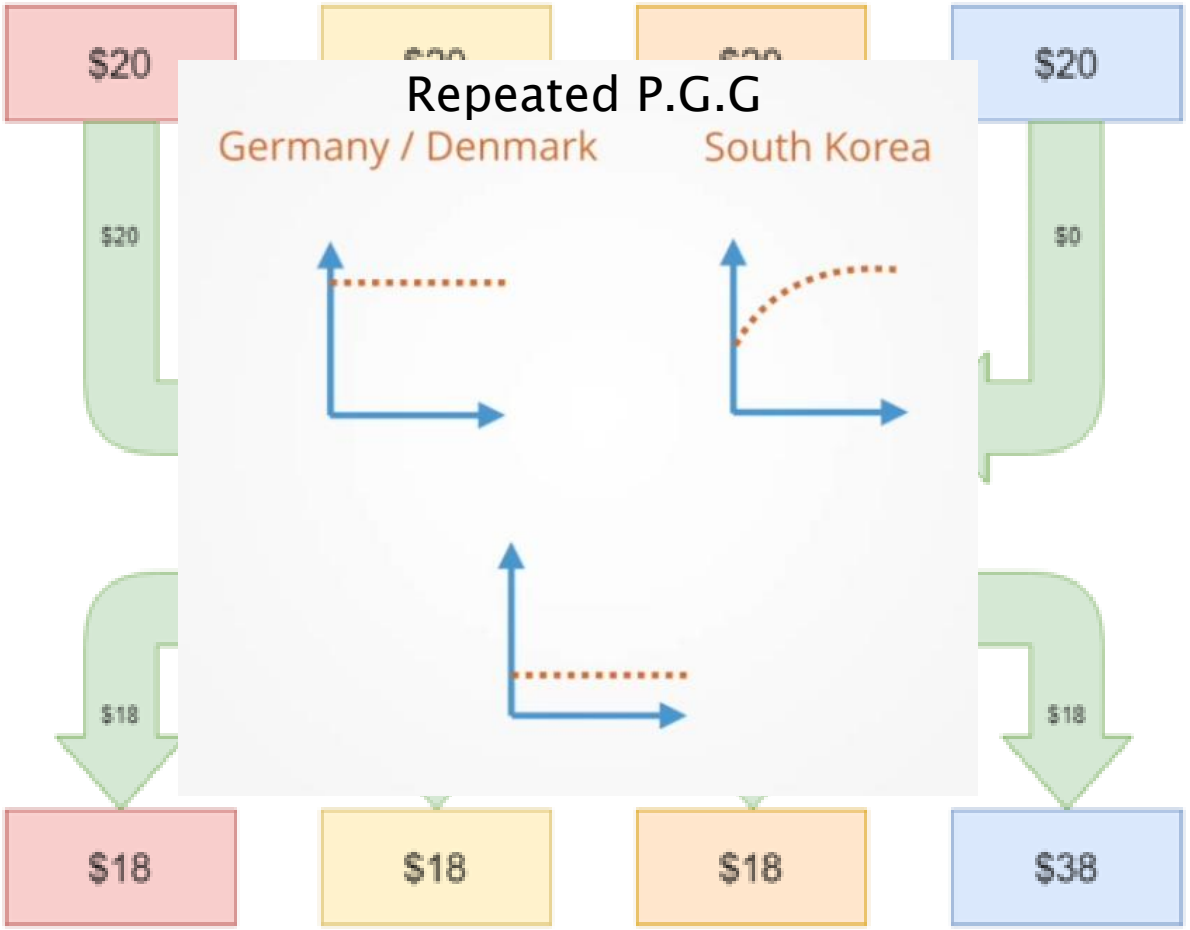
Giving



Taking

Experimental data is inconsistent !

Public Goods Game (Reinforcement learning)



https://www.youtube.com/watch?v=IwyPEFC4Tsk&t=115s

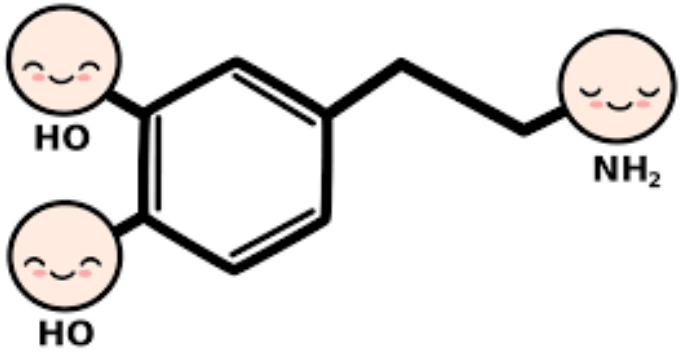
Experimental data is inconsistent !

- Güth, Schmittberger, Schwarze (1983)
  - ✓ They did the first experimental study on this game.
  - ✓ The mean offer was 37% of the “pie”
- Since then several other studies has been conducted to examine this gap between experiment and theory.
- Almost all show that humans disregard the rational solution in favor of some notion of fairness*.
  - ✓ The average offers are in the region of 40-50% of the pie
  - ✓ About half of the responders reject offers below 30%

Responder Irrationality ?

Rejection

- Pleasure to punish
- Inequity aversion
- Spiteful preference



Proposer Irrationality?

Proposer

- A taste of fairness (altruistic component)
- Fear of rejection (low offer will be rejected)
- Moral Preference?

Prospect theory vs. Expected utility theory

- Expected utility theory suggests that individuals can determine expected values of risky prospects and make choices consistent with utility maximization.
- Prospect theory-people are not good intuitive statisticians. Likely outcomes are estimated to be less probable than they really are; and outcomes that are quite unlikely are typically estimated to be more probable than they are. Furthermore, people often behave as if extremely unlikely, but still possible, outcomes have no chance whatsoever of occurring.

$$V(x,p) = W(p_1)v(x_1) + W(p_2)v(x_2) + \cdots W(p_n)v(x_n)$$

$$= \sum_{i=1}^{n} W(p_i)v(x_i)$$

$$W(p) = \frac{p^{\gamma}}{p^{\gamma} + (1-p)^{\gamma}}$$

$$V(x) = \begin{cases} x^{\propto}, & if\ x \geq 0 \\ -\lambda(-x)^{\beta}, & if\ x < 0 \end{cases}$$

α sensitivity to gain and ß sensitivity to loss

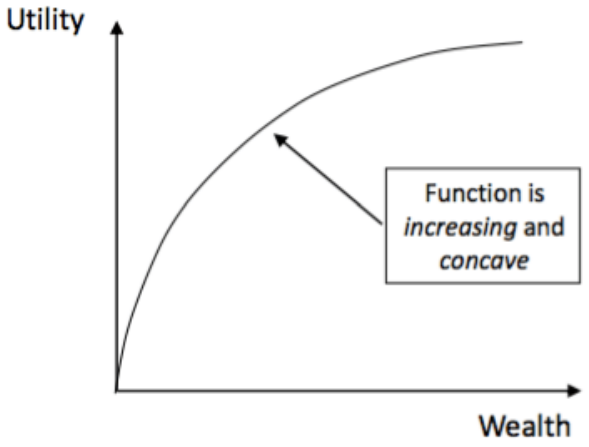
ʎ is overall concavity; individual are more sensitive to loss than gain.

γ is propbability weight parameter

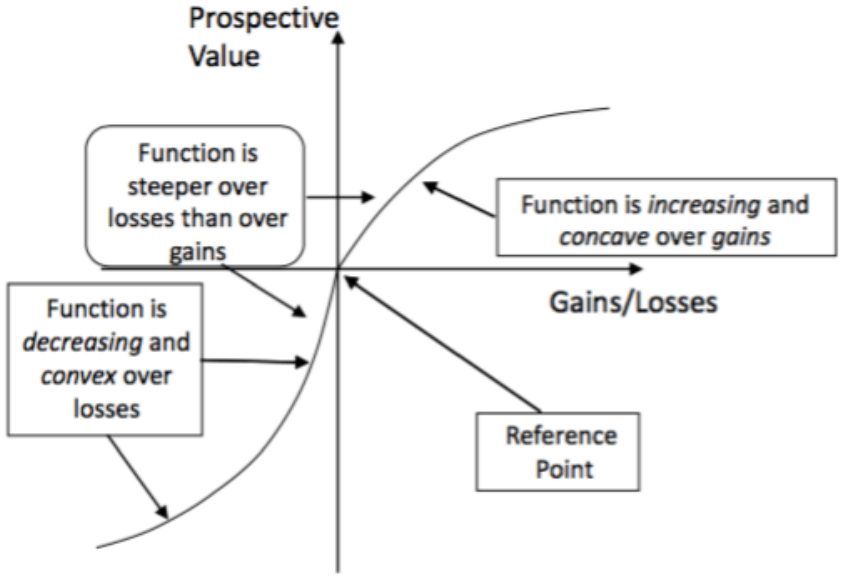
Kahneman and Tversky : α = β=0.88 , ʎ=2.25

Expected Utility (EU) versus Prospect Theory (PT)

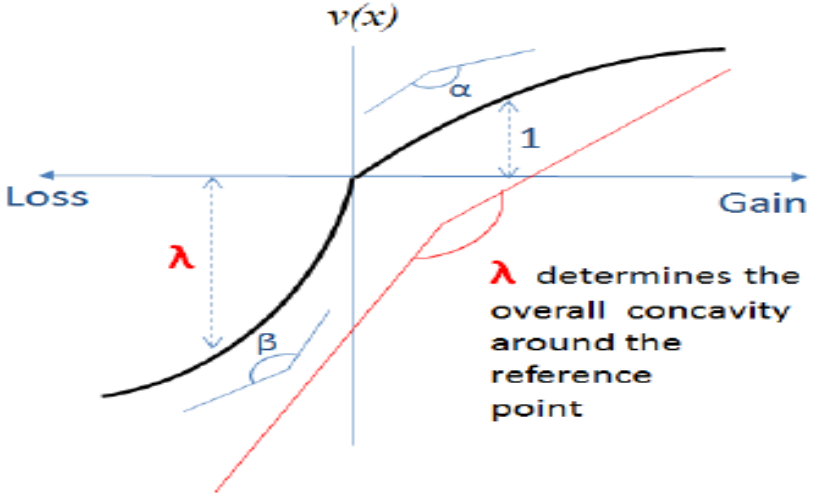
Expected Utility Theory



Prospect Theory

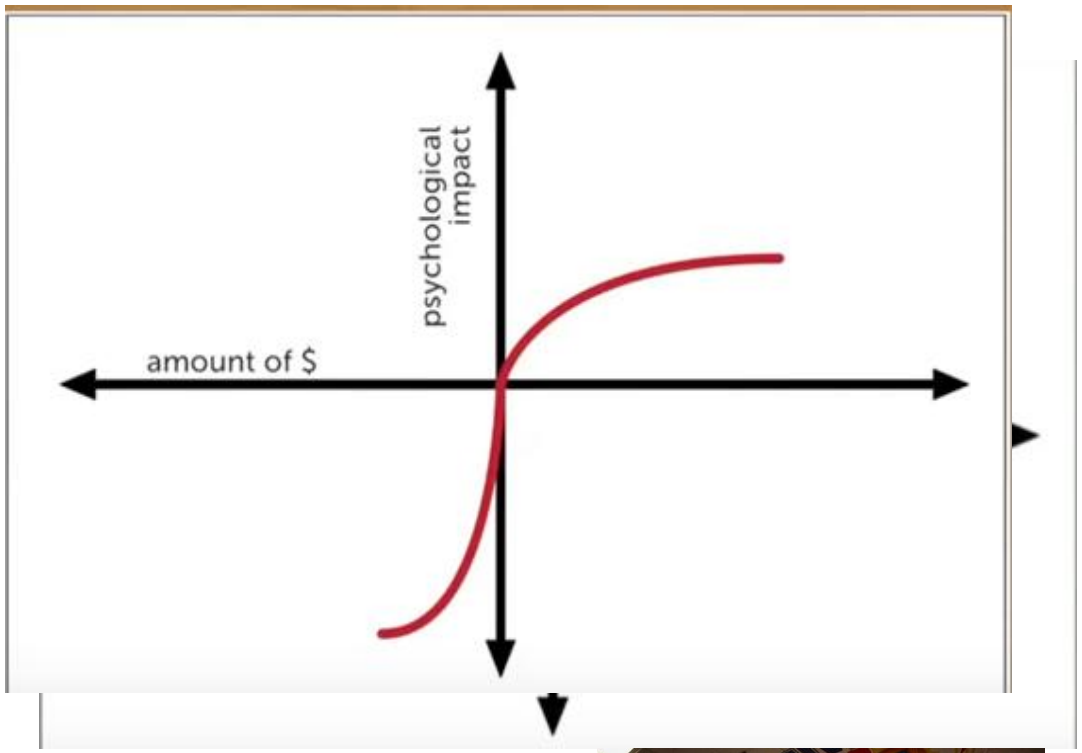


2-2.5 times steeper in losses, people feel losses more than gains. values from losses are greater than values from the same amount of gains(asymmetric)

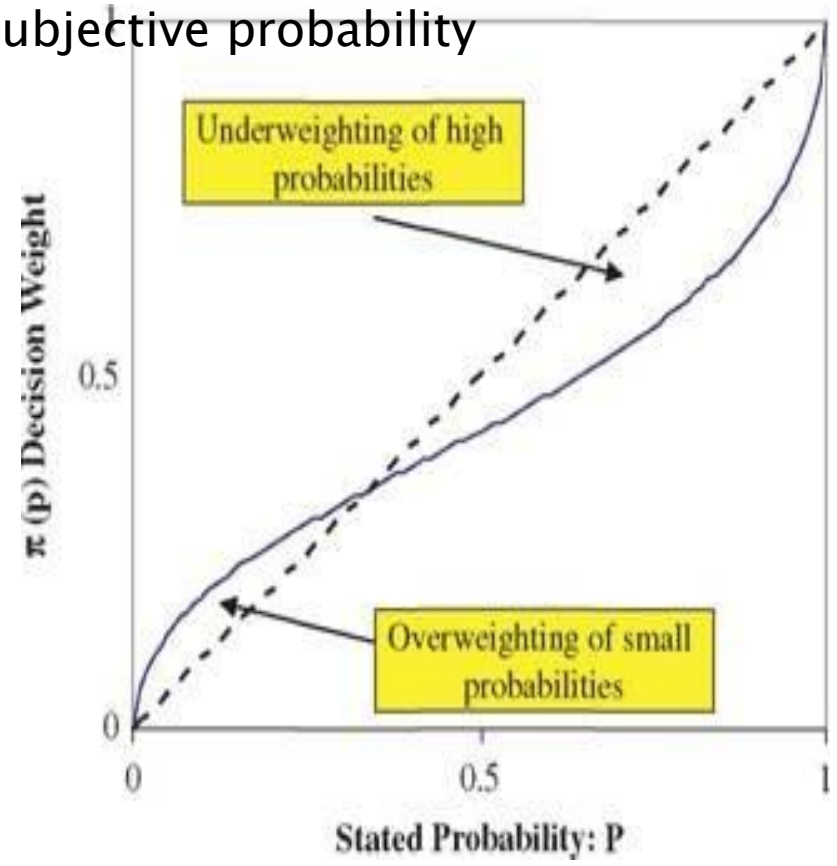


https://decisionsciences.shinyapps.io/Shiny/pt_qtd_shiny.Rmd

Prospect theory



Subjective probability



Objective probability

- (Adam Smith 1759, Parte VI)

among our equals is perhaps, the strongest of all our desires; and our anxiety to obtain the advantages of fortune is, accordingly, much more excited and irritated by this desire, than by that of supplying all the necessities and conveniencies of the body, which are always very easily supplied.

Our rank and credit among our equals, too, depend very much upon what, perhaps, a virtuous man would wish them to depend entirely,—our character and conduct, or upon the confidence, esteem, and good-will, which these naturally excite in the people we live with.

The care of the health, of the fortune, of the rank and reputation of the individual, the objects upon which his comfort and happiness in this life are supposed principally to depend, is considered as the proper business of that virtue which is commonly called prudence.

We suffer more, it has already been observed, when we fall from a better to a worse situation, than we ever enjoy when we rise from a worse to a better. Security, therefore, is the first and the principal object of prudence. It is averse to expose our health, our fortune, our rank, or reputation, to any sort of hazard. It is rather cautious than enterprising, and more anxious to preserve the advantages which we already possess than forward to prompt us to the acquisition of still greater advantages. The methods of improving our fortune, which it principally recommends to us, are those which expose to no loss or hazard; real knowledge and skill in our trade or profession, assiduity and industry in the exercise of it, fru-

Policy Evaluation Framework
چارچوب ارزیابی سیاست

نقطه کانونی (Focal Point) به سیاستگذار می‌گوید:چگونه سیاست می‌تواند انتظارات را هماهنگ کند؟

نش (Nash) می‌گوید:آیا رفتار حاصل پایدار است؟

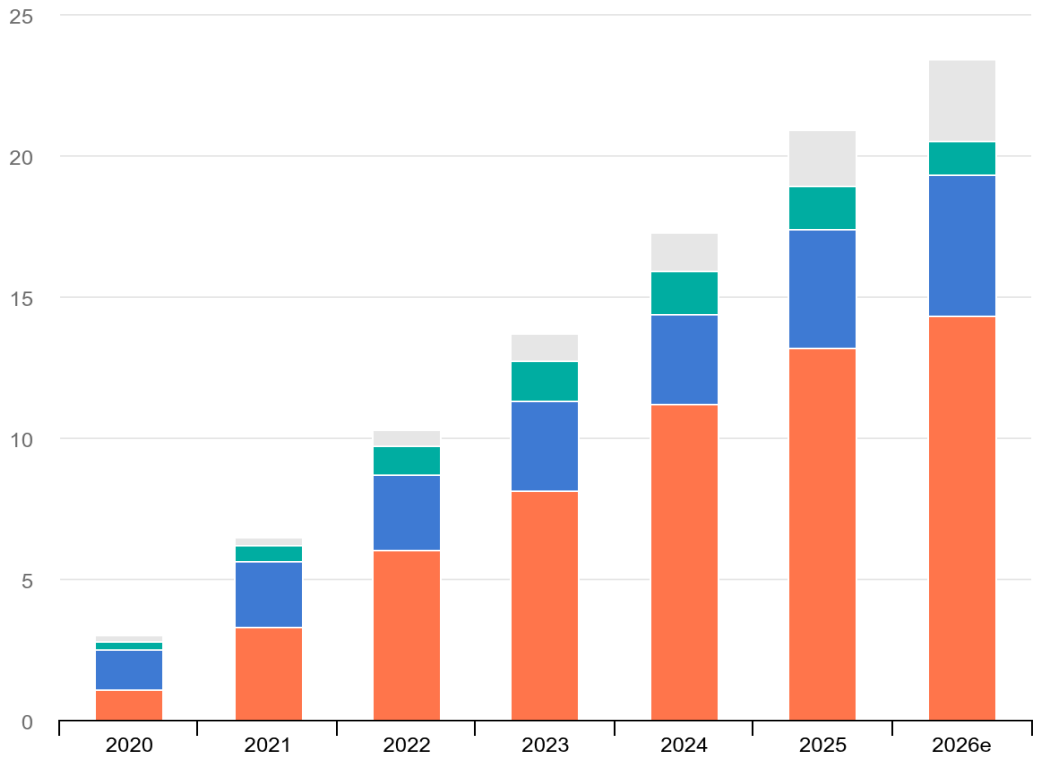
پارتو (Pareto) می‌گوید:آیا نتیجه از نظر کارایی قابل دفاع است؟

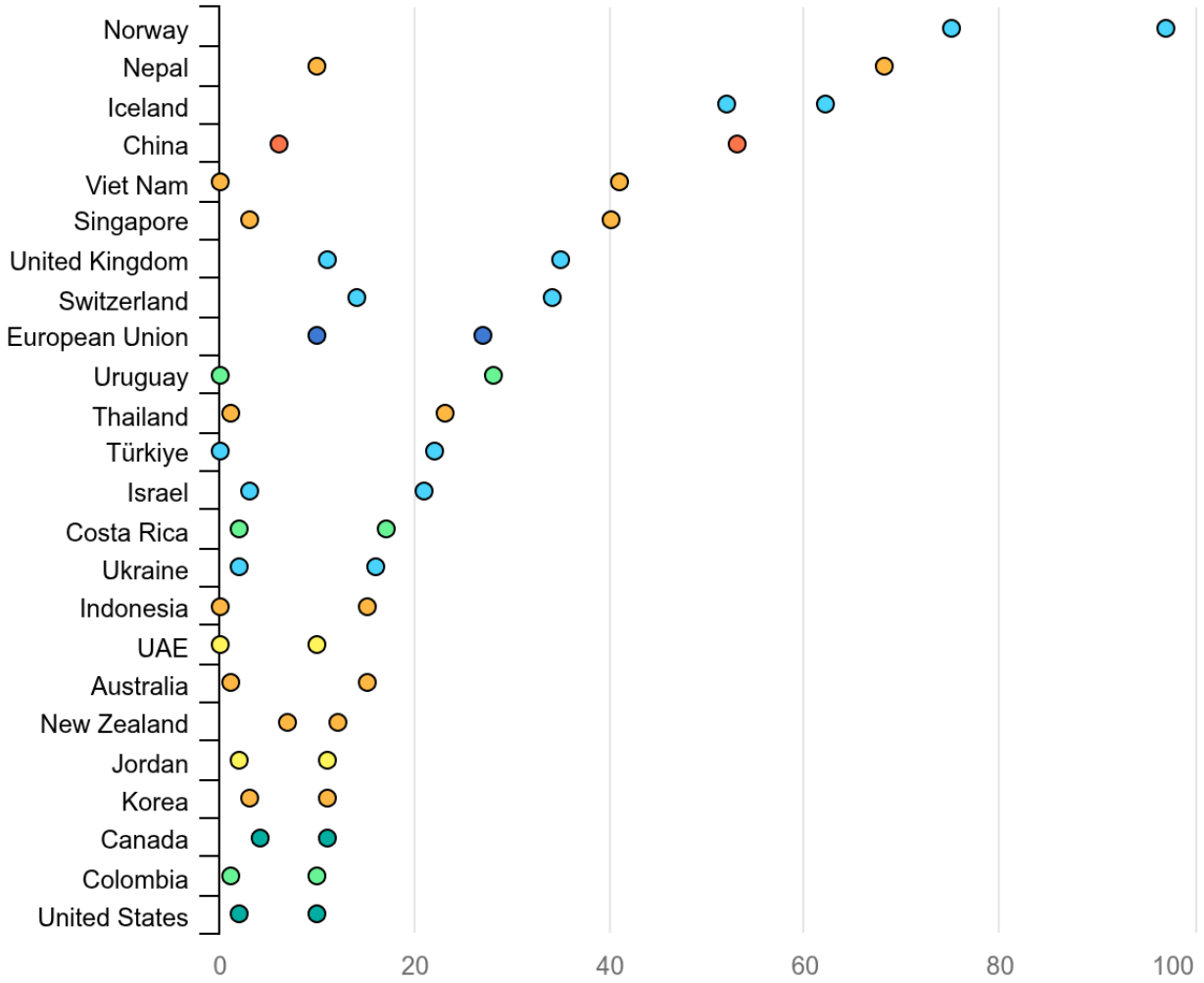
رالز(Rawls) می‌گوید:چه کسی از این سیاست سود می‌برد و چه کسی هزینه می‌دهد؟

(Amartya Sen) آمارتیاسن میگوید آیا همگان قابلیت استفاده از این سیاست را دارند؟

Trends in Electric Cars

One in four new cars sold worldwide was electric in 2025





https://www.iea.org/data-and-statistics/charts/electric-car-sales-share-for-countries-exceeding-10-2020-and-2025

Carbon Border Adjustment Mechanism (CBAM)
مکانیسم تعدیل کربن در مرز

CBAM در واقع به کارخانجات ایرانی اعلام میکند: آلودگی فقط یک مسئله زیست‌محیطی نیست؛ از این به بعد روی صادرات و رقابت‌پذیری اتان هم اثر می‌گذارد. پس یک کارخانه فولاد ایرانی ممکن است بگوید: اگر کوره و فناوری‌ام را کم‌کربن نکنم، صادراتم به اروپا گران‌تر می‌شود.

یعنی CBAM فقط یک مالیات مرزی نیست؛ یک سیگنال بسیار قوی درباره جهت آینده صنعت هم هست.و برای وزارت صمت ایران، سؤال سیاستی مهم این است:

آیا ما باید منتظر بمانیم CBAM هزینه‌ای به صادرات فولاد ایران تحمیل کند، یا قبل از آن با سیاست داخلی، بنگاه‌ها را به سمت فولاد کم‌کربن ببریم؟

چهار سؤال: Focal Point :آیا بنگاه‌ها باور می‌کنند آینده صنعت کم‌کربن است؟ Nash: آیا سرمایه‌گذاری سبز برای بنگاه به استراتژی پایدار تبدیل می‌شود؟ :Pareto:آیا کاهش کربن همراه با افزایش کارایی و رفاه است؟ Rawls :هزینه گذار سبز را چه کسی می‌دهد و آیا بنگاه‌های کوچک و نیروی کار حمایت می‌شوند؟

Supporting Green Industries

سوال سیاستی : آیا حمایت دولت می‌تواند با تغییر انتظارات بنگاه‌ها و مصرف‌کنندگان، اقتصاد را از یک تعادل «غیرسبز» به یک تعادل «سبز» منتقل کند؟

عنصر	توضیح
Policy Issue	گذار بنگاه‌ها از فناوری آلاینده به فناوری سبز
بازیگران اصلی	دولت، بنگاه‌ها و مصرف‌کنندگان
استراتژی دولت	S :حمایت از صنایع سبز / N :عدم حمایت
استراتژی بنگاه	G :سبز شدن / N : سبز نماندن
استراتژی مصرف‌کننده	B :خرید محصول سبز / N:خرید محصول غیرسبز
مسئله اصلی	هزینه بالای سرمایه‌گذاری اولیه و عدم اطمینان نسبت به تقاضای آینده
مسئله هماهنگی	بنگاه منتظر مصرف‌کننده است و مصرف‌کننده منتظر بنگاه

بازی فرضی دولت ،بنگاه و مصرف کننده برای سبز شدن بنگاه ها

Government Support (S)

Firm/Consumer	***Consumer (G)***	***Consumer (NG)***
Firm (G)	8,8,10	6,3,7
Firm (NG)	4,6,5	3,3,2

Government Not Support (N)		
Firm/Consumer	***Consumer (G)***	***Consumer (NG)***
Firm (G)	6,7,6	4,2,4
Firm (NG)	3,5,3	5,4,5

Estimating Payoffs and Choice Probabilities

برآورد پیامدها و احتمالات بازی

- $\pi_f = TR_{G(N)} - TC_{G(N)} - I + Sub - CO_2Cost$
- $U_c(G) = WTP_{G(N)} - P_{G(N)} + Env.Benefit$
- $W_{social.wel}(G) = Con.Surplus + Pro.Surplus + Env.Benefit - Tax$

$G = 1\ Green$
$G = 0\ Not\ Green$

$$P(G_i = 1) = \frac{1}{1 + e^{-Z_i}}$$

$$Z_i = \beta_0 + \beta_1 Sub_i + \beta_2 Carbon\ Price_i + \beta_3 EnergyPrice_i + \beta_4 FirmSize_i + \beta_5 Demand_i$$