Extended slides
this is an extended version (much more crowded with text and with additional explanations) of the slides I will project in the (virtual asynchronous) lectures. You can use them as lecture notes.

1 – Society: Coordination Problems & Economic Institutions

Study Materials for this Section (available on Moodle):

- Textbook Chapter 1 “Society: coordination problems & economic institutions” [main]
    - Note: you can skip Section 1.15 (“Application: Segregation as a Nash equilibrium among people who prefer integration”)
- The Economist: “Game Theory: Prison Breakthrough” [additional]

1 – Society: Coordination Problems & Institutions

- When do economic interactions produce outcomes that are economically *efficient* for society?
- When do they lead to outcomes that no one would have desired?
- What does it mean for an economic outcome to be efficient for society?
- How can we represent economic interactions in a stylized way and predict their outcomes?

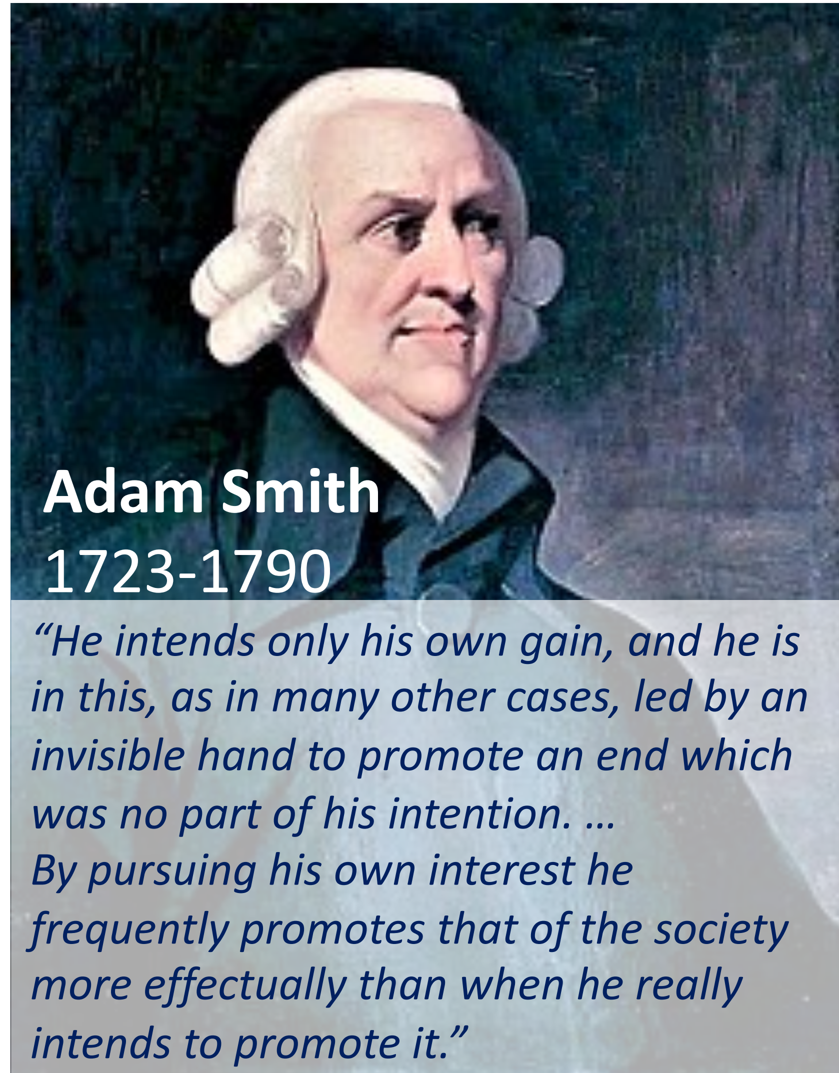
The Roadmap through Section 1

1. Coordination Problems
2. Games
3. Pareto efficiency
4. Types of Games
5. Institutions and Coordination Problems

The main ideas of this Chapter:

- Decentralized action can produce the most efficient outcomes for society….
- …but it can also produce outcomes that everyone would prefer to avoid;
- Sometimes there are different possible outcomes that are equally efficient for society, but they distribute the benefits in different ways, giving rise to conflicts of interest among people;
- Sometimes everyone agrees on which outcome would be best, but it is still difficult to get there;
- By setting "the rules of the game", institutions can address coordination problems (or they can make them worse).

Our guides to Section 1



"…Palanpur farmers sow their winter crops several weeks after the date at which they could maximize crop yields.

The farmers do not doubt that earlier planting would give them larger harvests, but no one is willing to be the first to plant their seeds, as the seeds on any lone plot would be quickly eaten by birds.

I asked if a large group of farmers, perhaps relatives, had ever agreed to sow their seeds earlier, all planting their seeds on the same day to minimize the losses. "If we knew how to do that, [the farmer] said, we would not be poor".

(from the textbook)

Russeau's stag hunt

"Were it a matter of catching a deer, everyone was quite aware that he must faithfully keep to his post in order to achieve this purpose; but if a hare happened to pass within reach of one of them, no doubt he would have pursued it without giving it a second thought, and that, having obtained his prey he cared very little about causing his companions to miss theirs."

Jean-Jacques Russeau (1755)

- Coordination Failures: people trying to do their best individually can collectively produce inefficient, undesirable outcomes, because they don't coordinate their actions.
  (farmers in Palanpur and the Russeau's stag hunt are two examples of coordination failures.)

- Classical Institutional Challenge:
  How to get the "rules of the game" right.
  How to design a constitution (a set of institutions: rules governing people's behavior) so that people can be left on their own devices, independent and free, but at the same time avoid inefficient outcomes.
  (*David Hume, Jean Jacques Rousseau*)

  – Another way to put it:
    The Classical Institutional Challenge asks: how can social interactions be structured so that people are free to choose their own actions while at the same time avoiding outcomes that none would have chosen?

- On the one hand, under capitalism, individuals acting mostly independently, seeking their personal objectives, have produced an unprecedented long-term increase in average living standards (the *invisible hand*).
- On the other hand, uncoordinated activities are also producing outcomes that are bad for everyone (*coordination problems*):
  – Overuse of natural resources;
  – Excessive pollution, climate change;
  – Unemployment (underuse of human resources);
  – Financial Crises;
  – Underuse of vaccines - overuse of antibiotics;
  – Team works that fail because everyone tries to just rely on the effort of others.

- **Externalities** (or external effects) are the reason why coordination failures occur.
- **Each individual** with her actions affects the well-being of others, but does not take that into account when making decisions.
- **Internalizing externalities** (= taking adequate account of the effect of our actions on others) would solve coordination failures, and fix the classical institutional challenge (easier said than done!)

Coordination Failures

- **Overuse** of certain resources can produce bad effects, e.g. carbon emissions, that have wide-scale results like climate change.
- Overuse is a type of coordination failure that occurs when there are **negative external effects.**
- People don't pay for the **cost** of their own actions on others.

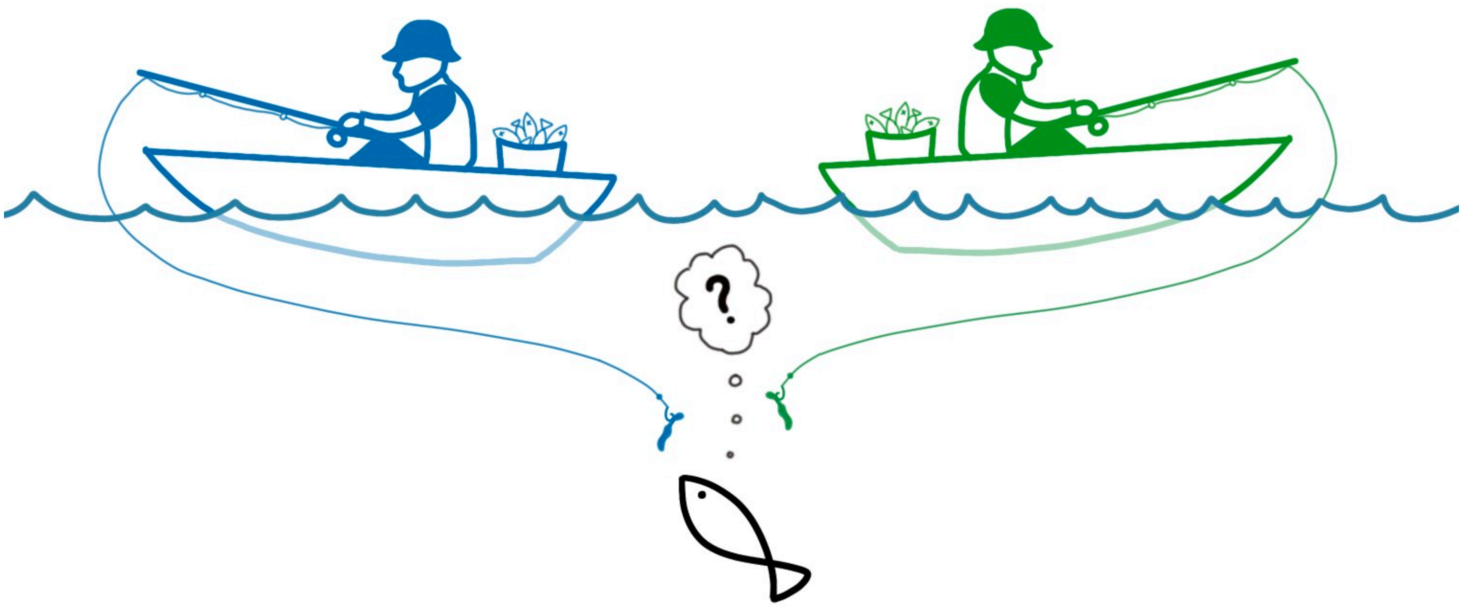
2 – Games

- Game Theory can be used to model social interactions and help understand coordination failures more deeply.
- In a game:
  - each player has a set of alternative actions available to her.
  - The outcome (payoff, utility) she will get depends on both her own actions and the actions of every other participant.
- Interdependence: what you get depends not only on what *you* do, but also on what *others* do [*social* interaction].
- Institutions ("the rules of the game") determine which actions are available to whom, and who gets what in each possible outcome.

The basic ingredients of a **game**:

- Players
- Strategy Set (the actions available to players)
- Payoffs (what players get in each possible combination of actions, or *strategy profile*)
- Order of play (simultaneous or sequential)
- Information structure (what do players know)

The Fishermen's Dilemma



The fishermen’s dilemma

- Alfredo and Bob share a lake and go fishing in it.
- As one catches more fish, the other catches fewer (externality)
- Each must decide how long to fish for: (10 or 12 hours).
- Fishing longer costly (time and effort) but yields more fish.
- If both fish 12 hours, they each catch fewer fishes per hour, while spending a lot of time and effort. Each gets a payoff of 2
- If they both fish 10 hours, they spend less hours but catch more fishes per hour. Each gets a payoff of 3.
- If Alfredo fishes 10 hours and Bob 12 hours, A gets few fishes while B gets a lot. Alfredo gets 1, Bob gets 4.
- If Al fishes 12 hours and Bob 10 hours, Al gets 4, Bob gets 1.

2 – Games

A strategic (or normal) form game:

The fishermen dilemma

		Bob	
		Fish 10 hours	Fish 12 hours
Alfredo	Fish 10 hours	3, 3	1, 4
	Fish 12 hours	4, 1	2, 2

A strategic (or normal) form game

If both fish 10h, they both get a payoff of 3

If Al fishes 10h and Bob fishes 12h, Al gets 1 and Bob gets 4

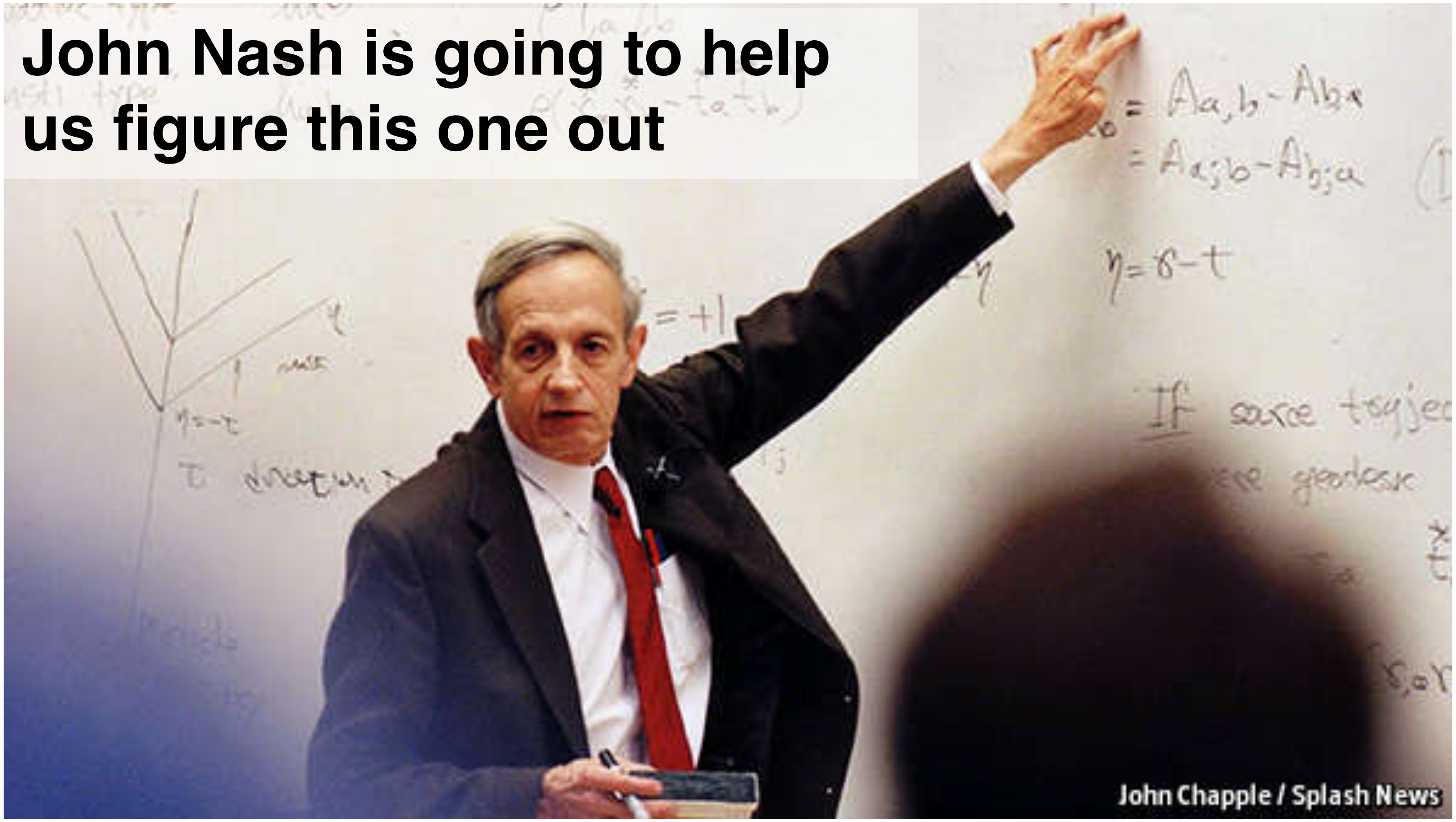
		Bob	
		Fish 10 hours	Fish 12 hours
Alfredo	Fish 10 hours	3, 3	1, 4
	Fish 12 hours	4, 1	2, 2

If Al fishes 12h and Bob fishes 10h, Al gets 4 and Bob gets 1

If both fish 12h, they both get a payoff of 2

How do we **predict the outcome** of a game?

John Nash is going to help us figure this one out



- **Best response:**
  the *best response of player A to strategy X of player B* is the strategy that gives A the highest payoff when B chooses strategy X.

➢ Equilibrium

A solution must be an *equilibrium.*

An outcome is an equilibrium if it is *stationary*: no one could do better by (individually) changing her/his strategy.

If this was not the case, that outcome would never be how the game ends!

3 steps to find the *Nash Equilibrium*:

1. Find the best responses of A, given each possible strategy of B.
2. Find the best responses of B, given each possible strategy of A.
3. The strategy profiles in which both players are 'best responding' to each other's strategies are the Nash Equilibria (may be one or more).

1 – Let's look at Alfredo's ***best responses*** to each possible action of Bob:

		Bob	
		Fish 10 hours	Fish 12 hours
Alfredo	Fish 10 hours	3, 3	1, 4
	Fish 12 hours	4, 1	2, 2

If Bob fishes 10h, Al's best response is to fish 12h (because 4>3)

If Bob fishes 12h, Al's best response is to fish 12h (because 2>1)

2 – Let's now add Bob's ***best responses*** to each possible strategy of Alfredo.

Bob (columns) / **Alfredo** (rows)

	Fish 10 hours	Fish 12 hours
Fish 10 hours	3, 3	1, 4
Fish 12 hours	4, 1	2, 2

If Al fishes 10h, Bob's best response is to fish 12h (because 4>3

If Al fishes 12h, Bob's best response is to fish 12h (because 2>1)

2 – Games

3 – Find the N.E. (strategy profiles in which both strategies are best responses).

(10,10) is not a N.E.: *each could move to 12h and gain more.*

(10,12) is not a N.E.: *Al could move to 12h and gain more.*

		Bob	
		Fish 10 hours	Fish 12 hours
Alfredo	Fish 10 hours	3, 3	1, 4
	Fish 12 hours	4, 1	2, 2

(12,10) is not a N.E.: *Bob could move to 12h and gain more.*

(12,12) is a N.E.: *Both are playing a best response given the strategy of the other.*

2 – Games

- A Nash equilibrium is a situation in which no player has a reason to change her strategy, as long as the other players do not change theirs.
- In a Nash equilibrium, the strategy of each player is a best response given the strategies of the other players (mutual best response).

- In a N.E., everyone is doing the best they can, given the actions of the others.
- In a N.E., no one is able to improve their own situation by changing their strategy.
- The definition of N.E. leaves unexplained *how the equilibrium will be reached*. But we know that *once we get there*, no one will have an incentive to move away.
- A N.E. is *not* guaranteed to be a ‘good’ solution.

Nash Equilibrium vs. dominant strategy equilibrium

- A strategy is strictly dominant if it is the player's strong best response to all possible strategy profiles of the other player(s);
- if each player has a strictly dominant strategy, we have a dominant strategy equilibrium;
- in a dominant strategy equilibrium, each player has a unique strategy that is optimal, no matter what the others do (little interaction);
- dominant strategy eq. is always a N.E. But a N.E. may not be a dominant strategy eq.

Is the Nash Equilibrium of the fishermen dilemma a dominant strategy equilibrium?

Yes! For both players, fishing 12 hours is the best response to all possible actions of the other player.

		Bob: Fish 10 hours	Bob: Fish 12 hours
Alfredo	Fish 10 hours	3, 3	1, <u>4</u>
	Fish 12 hours	<u>4</u>, 1	<u>2</u>, <u>2</u>

Find the N.E. of this game

A and B are two thieves that have been caught by the police. They are interrogated separately.

Player B

Player A

	Snitch	Keep quiet
Snitch	1, 1	3, 0
Keep quiet	0, 3	2, 2

- If they both snitch on each other, they both get 10yrs of jail (payoff=1).
- If one snitches and the other stays silent, the snitch gets free (payoff=3), the other goes to jail for 20yrs (payoff=0).
- If both keep quiet, they get away with just six months of prison each (payoff=2).

(Snitch, Snitch) is the Nash Equilibrium

A and B are two thieves that have been caught by the police. They are interrogated separately.

Player B

		Snitch	Keep quiet
Player A	Snitch	1, 1	3, 0
	Keep quiet	0, 3	2, 2

- If they both snitch on each other, they both get 10yrs of jail (payoff=1).
- If one snitches and the other stays silent, the snitch gets free (payoff=3), the other goes to jail for 20yrs (payoff=0).
- If both keep quiet, they get away with just six months of prison each (payoff=2).

2 – Games

- The game you just solved is a classic game called the ‘prisoners dilemma’.
- The fishermen dilemma and the prisoners dilemma have something in common: pursuit of self-interest brings to an outcome that all players would have preferred to avoid (Coordination problems).
- In the fishermen dilemma, Alfredo and Bob would both get an higher payoff by fishing 10h, with respect to what they get in the N.E.
- In the prisoners dilemma, both thieves would be better if they both stayed quiet.

Does the N.E. provide a good description of how these kind of *strategic interactions* will unfold in reality?

- Often, it does. (especially if players cannot coordinate their actions and don’t care about each other)
- But not always!

Possible problems with the N.E.

It overlooks opportunities to coordinate

Imagine the two fishermen could sign a contract agreeing to fish 10h each, with a sizable penalty if one breaks the contract. Two rational fishers would be eager to sign that contract.

It assumes self-interest

If Alfredo and Bob cared about each other, fishing 10h each would be a sustainable equilibrium: none would increase their fishing hours, because none would want to damage the other.

There may be multiple equilibria

In some games, you can have more than one NE. Which one should we expect to be realized?

Ignores dynamics

Does not tell us how the equilibrium would be reached. But sometimes that's the main thing we would like to know.

2 – Games

What makes it difficult to just agree on cooperating? (fishing 10h, keeping quiet…)

- Information: how do you check if the other is respecting the agreement? One could agree to cooperate but actually defect and get the biggest payoff!
- Enforcement: even if you can check on the other, how do you force him to comply?
- Distribution of benefits: Cooperating yields some extra-benefits. How to distribute them?

These difficulties with cooperating mean that in situations like the Fishermen Dilemma or the Prisoners' dilemma, the Nash Equilibrium might prevail and persist, even though it's bad for everyone.

3 – Pareto efficiency

- In coordination failures, decentralized pursuit of self-interest brings about socially inefficient outcomes (think of the fishermen).
- But how do we determine if an outcome is socially efficient? How do we go about comparing outcomes?
- One criterion is Pareto efficiency:
  - A is Pareto superior to B if no participant prefers B over A, and at least one prefers A (*Pareto comparison*).
  - An outcome is Pareto efficient if no other feasible outcome is Pareto superior to it.

Pareto efficiency in the fishermen dilemma

		Bob	
		Fish 10 hours	Fish 12 hours
Al	Fish 10 hours	3, 3	1, 4
	Fish 12 hours	4, 1	2, 2

- Three Pareto-efficient outcomes:
  - (10h, 10h);
  - (12h, 10h);
  - (10h, 12h)
- One outcome is *not* Pareto efficient: the N.E.! (12h, 12h)

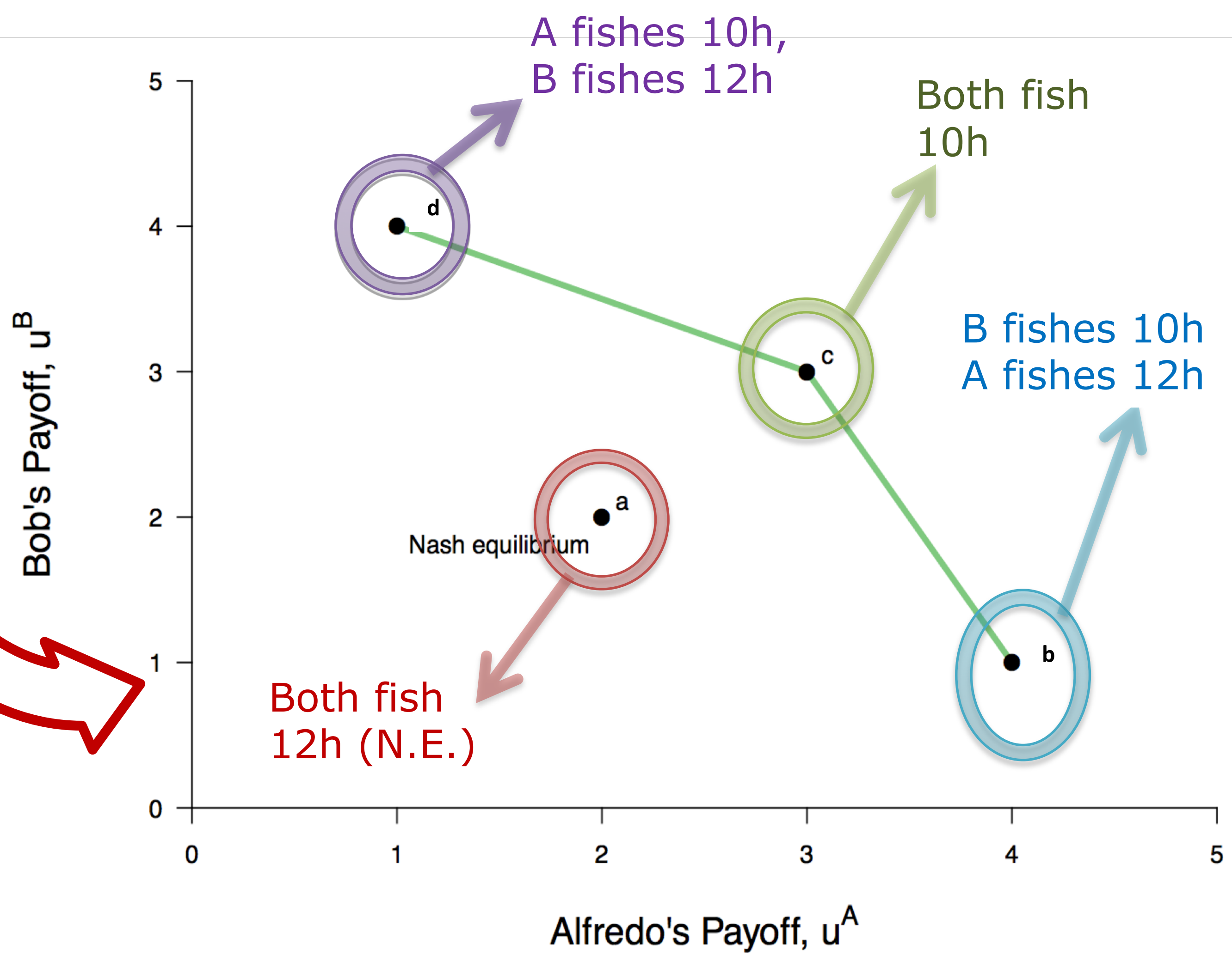
(make sure you understand why, by applying the definition of Pareto efficiency)

Using a graph to see Pareto efficiency

- We can plot the outcomes of a game, to assess Pareto-efficiency visually.
- To plot the outcome of a game:
  - represent the payoff of Player A on the horizontal axis, and the payoff of Player B on the vertical axis.
  - Find the points in the graph (a point being a combination of payoffs for the two players) corresponding to each possible outcome of the game.

This is the plot of the fishermen dilemma:

Al \ Bob	Fish 10h	Fish 12h
Fish 10h	3, 3 **{c}**	1, 4 **{d}**
Fish 12h	4, 1 **{b}**	2, 2 **{a}**



3 – Pareto efficiency

Now we can assess Pareto efficiency visually, using the following rule:

Outcome X is Pareto-superior to outcome Y if X lies to the north-east of Y in the plot.

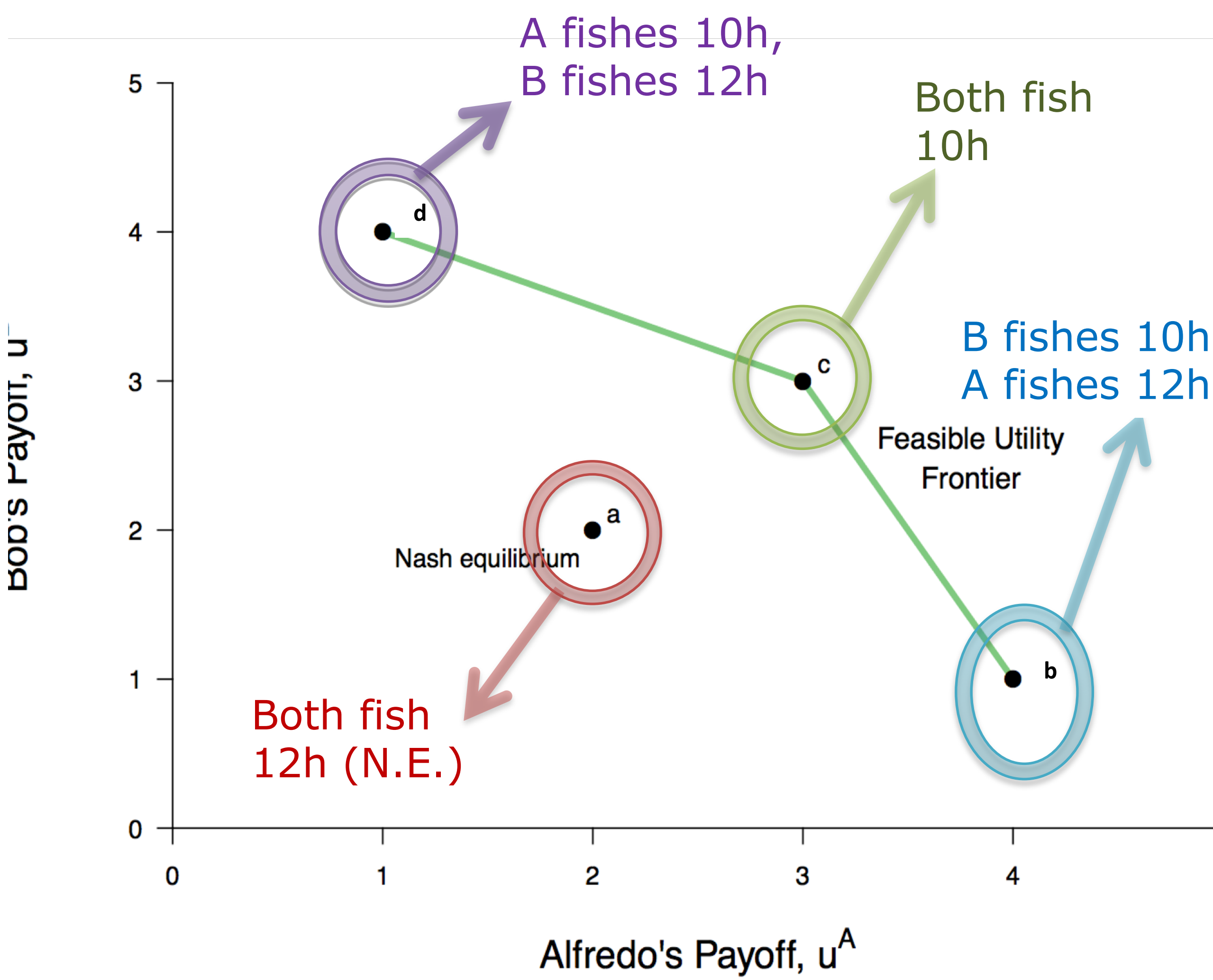
This is because if X is north-east of Y, it means both players get a higher payoff in X relative to Y (or one gets a higher payoff and the other gets the same).

The rule below also follows:

Outcome X is Pareto-efficient if there is no feasible outcome that lies to the north-east of X.

In the case of the Fishermen Dilemma:

- **c** lies north-east of **a**. So **c** is Pareto-superior to **a**.
- **d**, **c** and **b** are Pareto efficient (for each, can't find an outcome that lies north east of it).
- **a** is not Pareto efficient (there is an outcome that lies north-east of it).



Introducing some new concepts

Fallback position (also called *next best alternative*, or *participation constraint*): the payoff a player will get in the absence of cooperation. In the case of a fishermen, it is the payoff she gets in the Nash Equilibrium (that is, 2).

Economic rent: the increase in pay-off that can be achieved through cooperation. It is equal to the difference between the payoff that a player receives and her fallback position.

Economic surplus: the sum of the economic rents received by all participants in an interaction.

Strenghts of the Pareto criterion

- The Pareto criterion provides a fairly uncontroversial and objective way to identify the “bad” outcomes;
- It identifies outcomes that “none would have chosen”.
- If we are in a Pareto-inefficient outcome, we are foregoing an opportunity to make everyone better-off (or at least someone better-off and no one worse-off).

Shortcomings of the Pareto criterion

- Too strong: making only Pareto-efficient changes would bring to inertia.
  - *Usually, we have to go against some particular interest in order to benefit society as a whole. (ex.: taxing the super-rich to build schools). Pareto comparisons provide little info about these issues.*

- Too weak: it is not able to exclude outcomes that are "bad" because extremely inequitable and unfair.
  - *Take the problem of dividing up a pie. All the Pareto criterion says is "don't throw away any of the pie". But it cannot say that an outcome in which one player gets all the pie while the other starves is unfair.*

Pareto efficiency and the classical institutional challenge

- When it comes to addressing the classical institutional challenge, Pareto efficiency is necessary but not sufficient:
  - Good institutions should generally bring about Pareto efficient outcomes (no good food should be left on the table).
  - But good rules should also address important concerns of distribution and fairness, about which the Pareto criterion can't say anything.

- Now we can reformulate the definition of coordination problems in more specific terms:
  - *A coordination problem occurs when the non-cooperative interaction of two or more agents leads to a Nash equilibrium that is not Pareto efficient, or when there are multiple N.E.*

Classification of games

- do they present coordination problems?
- if yes, of which kind?

Invisible Hand games: no coordination problems; there is a unique N.E. and it is Pareto efficient.

Coordination games: decentralized N.E. not Pareto efficient, or multiple equilibria.
There are 3 types of coordination games:

- Prisoners' dilemmas (no Pareto-efficient N.E.)
- Assurance games (common interest)
- Disagreement games (conflict)

Consider the following game

		B	
		Corn	Tomato
A	Corn	1, 2.5	2, 2
	Tomato	4, 4	2.5, 1

An example of an Invisible Hand Game:

There is a unique N.E. and it is Pareto efficient.

Here decentralized action leads to socially efficient outcomes.

Your turn now!
Copy this payoff matrix (without the lines underlying best responses and the circle identifying the equilibrium) on a piece of paper, and make sure you know how to solve the game by yourself, without looking at this slide.

The "planting in Palanpur" game

B

A	Plant Early	Plant Late
Plant Early	4, 4	0, 3
Plant Late	3, 0	2, 2

coordination game
there is one Pareto inefficient N.E.

specifically, an assurance game:
players agree on which outcome would be best, but they need coordination to get there.

Two defining characteristics of Assurance Games:

– Multiple equilibria that are Pareto rankable
one is Pareto-superior to the other(s).

– Strategic complementarity
the payoff from a strategy is increasing in the number of players adopting it (feedback effects): you want to do what others are doing.

The language game

Ben (English-speaker)

Aisha (Swahili-speaker)

	Swahili	English
Swahili	4, 2	0, 0
English	1, 1	2, 4

coordination game
because of multiple equilibria

specifically, a disagreement game: multiple equilibria; all Pareto efficient.

- you cannot move from one N.E. to another without hurting somebody
- Players disagree on which NE is best.

- Players agree they should coordinate (choose same language) → strategic complementarity

- but they are in conflict over which outcome to coordinate on (Swahili or English?) → *conflict of interests*.

- Strategic complementarity: payoff from an action is higher if others are choosing that action as well.
  - Social media, for example, exhibit strategic complementarities. If all your friends use Whatsapp, you are more likely to want to use Whatsapp too. (Or Facebook, or Twitter…)
- Strategic complementarities often give rise to games with multiple Nash equilibria
- With multiple Nash equilibria, history matters:
  - if both farmers chose 'plant late' last season, they'll probably plant late also this season, given that no player has an incentive to change strategy individually.
  - therefore the equilibrium we find ourselves in might depend on the conditions we inherited from the past.
  - the same individuals, playing the same game, can end up in different equilibria depending on what was the initial situation. This is called *path dependence*.

- Coordination failures are Pareto-inefficient Nash Equilibria.
- If we want to eliminate them, we need to change the payoff structure of the game
  - ‘payoff structure’ just means “what payoff each player gets in each possible outcome”.
- In other words: we must change the rules of the game.
- The rules of the game generally depend on the institutional context.

Institutions determine the rules of the game

- Laws, social norms & conventions.
- Why do you drive on the right in the US?
  - Because otherwise you will be arrested (laws).
  - Because otherwise other people will think you are nuts and/or despise you (social norms).
  - Because you expect everyone else to do the same, so it would be very unsafe not to do it (conventions).

- By changing the rules of the game, institutions can address coordination problems.
- Two possible problems to be solved:
  - *How to get there?* If there is a Pareto efficient N.E., but we are stuck in an inefficient one (e.g. Assurance Game). Then we need a coordination device for people to converge on the efficient equilibrium.
  - *How to stay there?* If the efficient outcome is not a N.E. (e.g. Prisoner Dilemma), we need to change the payoff structure to make it a N.E.

How to 'break' a Prisoners Dilemma

- Prisoners dilemma: a unique and inefficient N.E. (like in the Fishermen Dilemma that we studied).
- Policy (institutions) can transform the payoff matrix to solve the coordination problem
- Take the fishermen dilemma.
- *Liability rule:* if you defect (fish 12h), you have compensate the other fisher for the reduction in welfare that you are causing to him.
- The institution of liability rule can turn a Prisoners Dilemma game (like the fishermen dilemma) into an Invisible Hand game.

The fishermen dilemma with a liability rule

Bob

Al	Fish 10h	Fish 12h
Fish 10h	3, 3	1+2, 4-2
Fish 12h	4-2, 1+2	2, 2

- Alfredo and Bob embrace 'cooperate' (fish 10h) as the norm for behavior
- They adopt a *liability rule*: *Anyone who violates the norm must compensate the other for the reduction in payoff caused by the violation*
- If Al violates the norm (fishes 12h), he initially gets 4
- But then he has to pay (3-1=2) to Bob, to compensate him for the cost of his 'betrayal'.
- If they both defect, they must compensate each other by an equal amount, so they remain at 2.

Now, after introducing the liability rule (an institution), the only Nash Equilibrium is both players fishing 10 hours, which is Pareto efficient. (And it is also a dominant strategy equilibrium, so it particularly robust!)

The fishermen dilemma with a liability rule

Bob

Al	Fish 10h	Fish 12h
Fish 10h	3, 3	1+2, 4-2
Fish 12h	4-2, 1+2	2, 2

- This re-definition of property rights succeeded!
- We have internalized the externalities, and now the unique Nash Equilibrium is Pareto efficient.
- A simple example of how institutions can address coordination problems.
- Of course things aren't always that easy: here we assumed that behavior is observable and that contracts are costless to enforce!