Reciprocity and collusion

UNITE 2022-2023

Introduction

We now turn to study reciprocity and cooperation in repeated interactions:

1. How and when do repeated interactions allow essentially selfish parties to cooperate?

2. After answering this question somewhat abstractly, we apply the answers to the subject of tacit and explicit collusion in oligopolies.

3.

A (classic) story

Large electric turbine generators are enormous, expensive pieces of capital equipment that turn mechanical energy into electricity.

They are essential to the production of electricity by large electric utilities, in applications where fossil fuels are burned, where steam is produced by nuclear reactors, and in large hydroelectric facilities.

In the late 1950s, large turbine generators for the U.S. market were produced by three large industrial firms: General Electric, Westinghouse, and Allis-Chalmers.

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A (classic) story

A Porteresque five-forces analysis of this industry as of the 1950s and 1960s leads to the conclusion that, at least potentially, this could have been a very profitable industry.

1. Entry barriers were absolutely formidable.
2. Complements i.e. fossil fuels were cheap;
3. Substitutes were not economical;
4. Suppliers to the industry were relatively weak;
5. Customers were relatively weak; were not very price sensitive and were under pressure to increase generating capacity.

A (classic) story

In the 1950s, the three firms reaped tremendous profits.

But in the early 1960s, they were much less profitable.

In fact, in the early 1960s, their levels of profit were so low that the smallest of the three, Allis-Chalmers, was driven out of the industry, leaving GE and Westinghouse to share very low levels of profit.

Yet by 1970, GE and Westinghouse were once again earning enormous profits.

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A (classic) story

The wide swings in profitability were due to changes in the nature of rivalry in the industry.

In the 1950s, GE, Westinghouse, and Allis-Chalmers found a very clever—**and utterly illegal**—way to coordinate their prices, leading to high profits.

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A (classic) story

In this business, a customer in need of a turbine generator would make a formal announcement of this fact, complete with specifications to be met, asking for potential suppliers to submit bids.

BEWARE: try not to laugh at the forthcoming slide! I AM BEING SERIOUS!!

A (classic) story

At the moment such a formal solicitation of bids was made, the three suppliers would consult a lunar calendar.

On Days 1 through 17 of the lunar month, GE was understood by the three firms to “own” the contract; GE would make a bid at a relatively high price, and Westinghouse and Allis-Chalmers would put in bids at even higher prices.

If the solicitation of bids occurred on Days 18 through 25 of the lunar month, Westinghouse was understood to “own” the contract.

And if it occurred on Days 26 through 28, Allis-Chalmers was understood to “own” the contract.

This collusive scheme had been arranged by the three in secret negotiations conducted in a hotel room.

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A (classic) story

This was a price-fixing conspiracy, directly violating the Sherman Antitrust Act.

It was so blatant a violation of U.S. antitrust law that, when the U.S. Department of Justice figured out the scheme, it pursued criminal charges against executives of the three firms and jail time was handed down.

But, because the people at the Department of Justice did not think to consult a lunar calendar, they did not figure out **how** the three firms were coordinating their bids for quite some time, and until the DoJ figured it out, the three firms made sizeable profits.

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A (classic) story

Kreps on this story: “This was simply magnificent! The Beethoven’s *Ninth Symphony* of business strategy.

Why did the moon’s phases scheme worked?

Why, then?

Suppose it is Day 25 of the lunar month, and Con Ed of New York solicits bids for a generator.

Westinghouse owns Day 25. So Westinghouse prepares a bid that leaves it with a substantial profit, expecting GE and A-C to make even higher bids.

Imagine you are the CEO of Allis-Chalmers. Your market share is, on average, around 10%, because you own only 3 days out of 28.

Moreover, the luck of the draw, combined with a slow market, may mean that you have not gotten an order for a year.

Why not defect from the agreement and steal this order from Westinghouse?

You need not fear that Westinghouse will take you to court for breaking this agreement: Since the deal is illegal, it is not enforceable in court. Why do you adhere to the deal?

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What now?

Our main subject is the answer to this question.

To be more precise: the answer to the question,

Under what conditions will parties to this sort of arrangement adhere to the deal they struck?

The general topic is reciprocity in repeated interactions:

How and when can we get cooperation from folks who are essentially selfish?

A Game-Theoretic Analysis of Reciprocity: The Folk Theorem

The story starts with the Prisoners'Dilemma.

Prisoners are now called Alice (row) and Bob (column).

Remember: Confessing is a dominant strategy for each side and, therefore, *confess–confess* is the only Nash equilibrium of the game.

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		Prisoner 2	
		remain silent	confess
Prisoner 1	remain silent	5, 5	–3, 8
	confess	8, –3	0, 0

A Game-Theoretic Analysis of Reciprocity: The Folk Theorem

- We already know what could enforce a cooperative solution.
- Consider now this possibility:

1. Alice and Bob play the game once, with the results revealed at the end of play.
2. Then some random event is conducted such that with probability 0.8, the two play a second time, while with probability 0.2, the encounter ends.

A Game-Theoretic Analysis of Reciprocity: The Folk Theorem

After they play the second time, if they do, the results are again revealed, and another random event is conducted independently, so the probability of going on to a third round of play is 0.8, and so on.

After each round of play, the chance of proceeding to another round is 0.8 and the chance that the encounter ends is 0.2, independent of what has happened in the past.

A Game-Theoretic Analysis of Reciprocity: The Folk Theorem

Assume that payoffs for a string of plays for each player are just the sum of their payoffs in each round;

and insofar as a player is uncertain what payoffs he or she will get, for instance, because of uncertainty concerning how long the game will last, the player seeks to maximize the *expected value* or probability-weighted average (mean) of his or her summed payoff.

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A Game-Theoretic Analysis of Reciprocity: The Folk Theorem

This is a fairly complex extensive-form game.

The tree, in other words, might never completely end (…and it is damn complicated).

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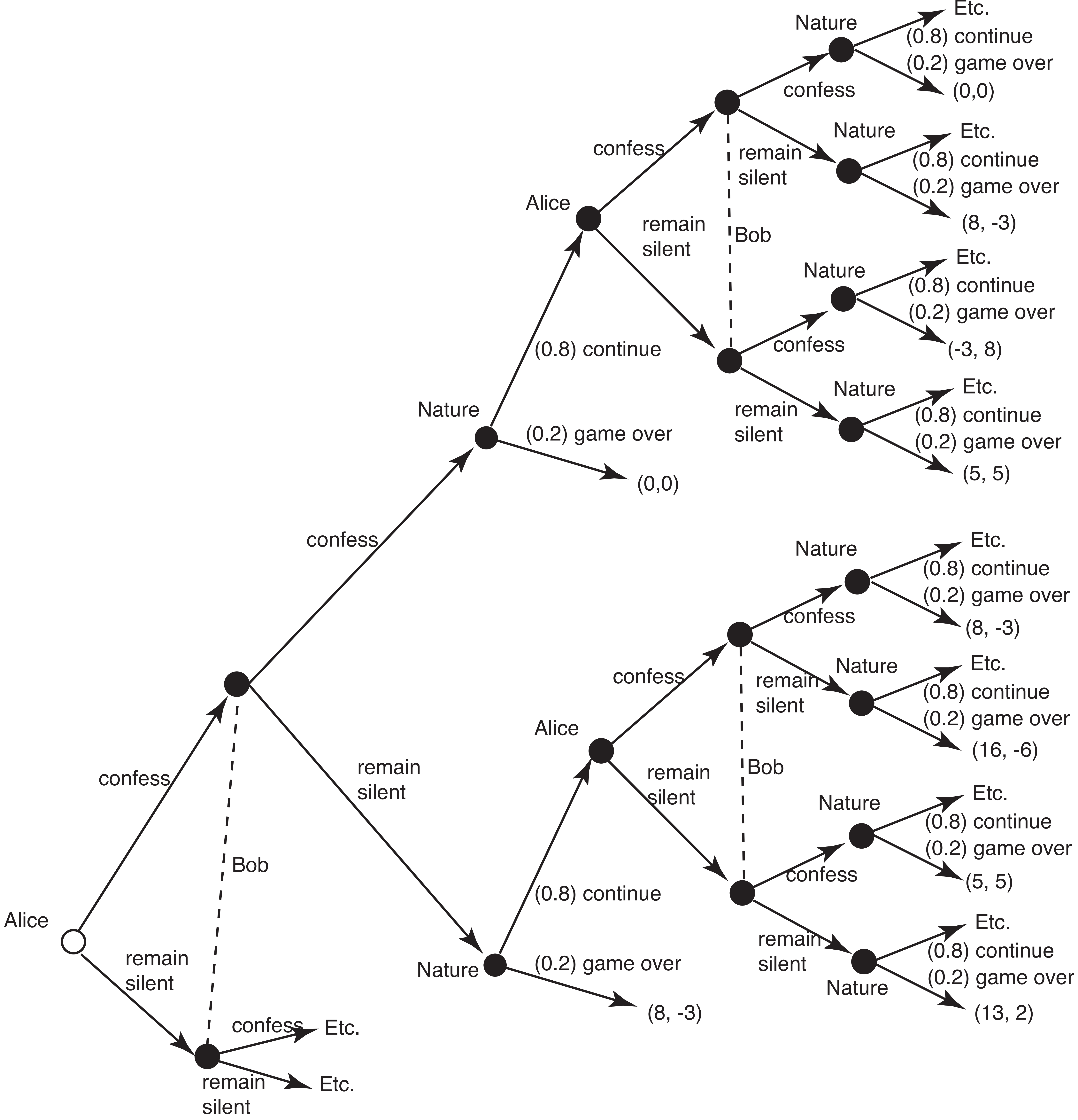
Alice
confess
remain silent
Bob
confess
Etc.
remain silent
Etc.
confess
Nature
(0.8) continue
(0.2) game over
(0,0)
Alice
confess
remain silent
Bob
confess
Nature
Etc.
(0.8) continue
(0.2) game over
(0,0)
remain silent
Nature
Etc.
(0.8) continue
(0.2) game over
(8, -3)
confess
Nature
Etc.
(0.8) continue
(0.2) game over
(-3, 8)
remain silent
Nature
Etc.
(0.8) continue
(0.2) game over
(5, 5)
remain silent
Nature
(0.8) continue
(0.2) game over
(8, -3)
Alice
confess
remain silent
Bob
confess
Nature
Etc.
(0.8) continue
(0.2) game over
(8, -3)
remain silent
Nature
Etc.
(0.8) continue
(0.2) game over
(16, -6)
confess
Nature
Etc.
(0.8) continue
(0.2) game over
(5, 5)
remain silent
Nature
Etc.
(0.8) continue
(0.2) game over
(13, 2)

A Game-Theoretic Analysis of Reciprocity: The Folk Theorem

Alice begins with confess.

But note a few things: It depicts Alice going “first” in each round, then Bob, with an information set for Bob, so he doesn’t know what Alice did that round, but with both Alice and Bob knowing what happened in round 1 when they move in round 2.

As for payoffs, look at the payoff vector (13, 2) near the bottom: This is the outcome (the payoffs) if, in the first round, Alice confesses and Bob remains silent (which gives Alice 8 and Bob -3), plus a second round in which the both remain silent (for 5 apiece): Alice totals 13, while Bob nets 2.

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A Game-Theoretic Analysis of Reciprocity: The Folk Theorem

It may sound hopeless, but by restricting attention to relatively simple strategies, we can still describe some interesting Nash equilibria of this simple yet formidable game.

To begin, consider the following four strategies:

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A Game-Theoretic Analysis of Reciprocity: The Folk Theorem

1. *Always confess*, which is just what it says: If Alice adopts this strategy, she will always confess, every chance she gets, no matter what happened earlier in the game.

A Game-Theoretic Analysis of Reciprocity: The Folk Theorem

1. *Always remain silent*, which we can (for reasons to be given momentarily) rename *Be a sap*. Just what it says.

A Game-Theoretic Analysis of Reciprocity: The Folk Theorem

The *Arthur Shelby's strategy*: On the first round, remain silent. On every subsequent round, remain silent if, on all previous rounds, your opponent remained silent. But if your opponent ever confessed on an earlier round, confess.

This is a strategy of "I'll cooperate with you as long as you never stab me in the back by confessing. But if you ever confess, that's it: I'm confessing forever, with no forgiveness for what you (once) did to me."

A Game-Theoretic Analysis of Reciprocity: The Folk Theorem

Tit-for-tat: On the first round, remain silent. On every subsequent round, do whatever your opponent did in the previous round.

A Game-Theoretic Analysis of Reciprocity: The Folk Theorem

For each of these, we can ask, If one player plays this strategy, what is the other player's best response?

A Game-Theoretic Analysis of Reciprocity: The Folk Theorem

If your opponent plays *always confess*, your best response, and your only best response, is *always confess*.

Nothing you do will affect what your opponent does in the future, so you might as well get as much as you can in each round.

That's *always confess*.

A Game-Theoretic Analysis of Reciprocity: The Folk Theorem

If your opponent plays *always remain silent*, your best response, and your only best response, is *always confess*.

Same reason: Your choice in any round has no impact on what your opponent does in the future, so your best response is to maximize each round what you get that round, which means *always confess*.

A Game-Theoretic Analysis of Reciprocity: The Folk Theorem

In fact, *always confess* is the unique best response to any *nonreactive* strategy by your opponent, meaning any strategy (for your opponent) where what you do in any round has no impact on what your opponent will do in the future.

But suppose your opponent chooses a reactive strategy such as the Arthur Shelby's strategy or tit-for-tat. Then matters become more complex.

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A Game-Theoretic Analysis of Reciprocity: The Folk Theorem

For one thing, against reactive strategies, you may have many best responses.

Suppose, for instance, your opponent plays *grim*, which certainly involves re-acting to what you do.

Then you never want to *initiate* confessing.

As long as you begin and stick with remaining silent, your opponent will reciprocate. That means you will get 5 in round 1, 5 in round 2, if there is a round 2, 5 in round 3, if there is a round 3, and so forth.

You could confess at any time, which would net you one 8 in the round that you confess. But, after that, your opponent is going to always confess, and the best you can do subsequently in each round is confess, which gets you 0.

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A Game-Theoretic Analysis of Reciprocity: The Folk Theorem

And, if you do the math,

5 this round,

5 next round with probability 0.8,

5 the round after that with probability 0.8 x 0.8 = 0.64 and so forth…

…[3] is better than 8 this round and 0 forever after.

Pause for a second

For those who know the math:

the expected value of never initiating confession is

$$5 + 0.8 \cdot 5 + 0.8 \text{x} 0.8_{2} \cdot 5 + 0.8 \text{x} 0.8 \text{x} 0.8 \cdot 5 \ \ldots = 5/(1 - 0.8) = 25.$$

we’ll return to this.

A Game-Theoretic Analysis of Reciprocity: The Folk Theorem

However, you have very many best responses to *grim*.

Always remain silent is a best response.

The *grim* strategy is a best response.

Tit-for-tat is a best response.

Any strategy that never *initiates* confessing is a best response.

Have these propositions proved as an exercise.

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