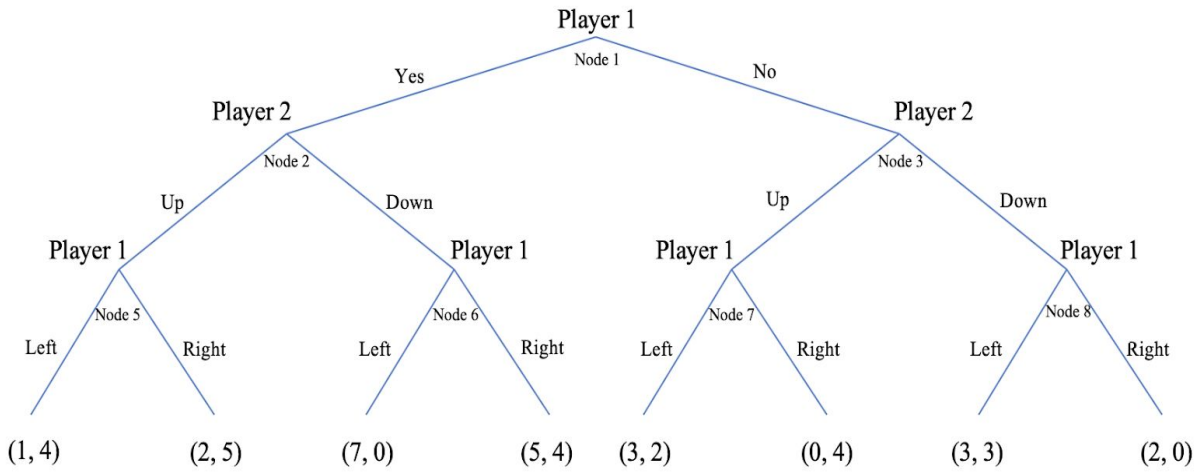
2019 Northwestern Economics Tournament

Power Round Answer Key

SET A (15 points)

Consider the game tree below. The game consists of two players and three rounds of actions. First, player one chooses "Yes" or "No" at node 1 of the game. Then, depending on player 1's choice, player two will choose "Up" or "Down" at either node 2 or node 3. This will take the game to node 5, 6, 7, or 8, where player 1 will move again. Player one will choose "left" or "right," and then both players will receive their payoffs from the game. Every possible outcome's playoffs are listed below the tree in parentheses, where player one's payoff is the first entry, and player two's payoff is listed second.



We will find the equilibrium of this game by using backwards induction.

A. Suppose player one is at node 5, and she must choose between "left" or "right." What is player one's best response in this case to maximize her payoff? Explain why you chose this. (2 points)

   Right- earn 2 rather than 1

B. In the same fashion as above, find player one's best responses at nodes 6, 7, and 8. Explain your answers. (6 points)

   6: Left- earn 7 over 5
   7: Left- earn 3 over 0
   8: Left- earn 3 over 2

C. Now, suppose player 2 is at node 2. What is player 2's best response between "up" and "down" at node 2? Explain your answer. (2 points)

Up- player 2 knows that player one will choose right at node 5 and left at node 6. So, player 2 will earn 5 from choosing up and 0 from choosing down.

D. In the same way as above, find player 2's best response at node 3. Explain your answer. (2 points)

Down- player two will earn 3 from down and 2 from up

E. Finally, use all of the information you've gathered to show what player one will choose at node 1. Explain. (3 points)

Player 1 will choose "no." The payoff reached from playing "yes" is 2, and the payoff from playing "no" is 3.

SET B (15 points)

In a fractional reserve banking system, banks keep only a certain amount of their deposits in reserves. Suppose that all banks in the economy keep (r*100)% of their deposits in reserve, where r is the reserve ratio, and assume that once loaned out, all dollars will re-enter the banking system as deposits.

A. What is the name of the organization within the United States government that is in charge of setting r? (1 point)
   Federal Reserve (System or Bank), also accept "Fed"

B. Suppose that r = 0.1. Bank A has $2000 in deposits, then decides to issue the maximum amount of loans.
   i. How much did Bank A loan out? (1 point) $1800

   ii. How much does Bank A have remaining in reserves? (1 point) $200

   iii. Draw the balance sheet for Bank A below. (1 point)

Balance Sheet for Bank A

Assets	Liabilities
Reserves $200 Loans $1800	Demand deposits $2000

Correct answer should include labels (reserves, loans, saying "deposits" simply or "checking accounts" should also be acceptable). Keep this guideline the same for questions (C) and (D)

C. Eventually, the money from Bank A's loans is deposited into Bank B. Bank B then issues loans for the maximum amount possible. Draw the balance sheet for Bank B below. (2 points)

Balance Sheet for Bank B

Assets	Liabilities
Reserves $180 Loans $1620	Demand deposits $1800

One point for correct labels (reserves, loans, and demand deposits)
One point for correct quantities

D. The money from Bank B's loans is deposited into Bank C. Bank C then issues loans for the maximum amount possible. Draw the balance sheet for Bank C below. (2 points)

Balance Sheet for Bank C

Assets	Liabilities
Reserves $162 Loans $1458	Demand deposits $1620

One point for correct labels (reserves, loans, and demand deposits)
One point for correct quantities

E. The process described above continues infinitely. Write an expression to describe M, the total money supply in the economy from the original deposit of $2000, in terms of the reserve ratio *r*. Show your work. (3 points)

M = 2000/r

Award two points if the expression is M = 2000/r - 2000 is provided.
Award one point if the answer given is 20,000, even if the expression above is not provided.
Award one point if the expression for the appropriate infinite series is provided, which can be in either of the following two forms:

(1) $2000 + 2000(1 - r) + 2000(1 - r)^2 + 2000(1 - r)^3 + ...$

(2) 2000 + 1800 + 1620 + 1458 + …

**Full points for an answer requires an expression in terms of *r*.

F. Student A claims that "Fractional reserve banking increases the liquidity of the economy." Student B says that "Fractional reserve banking creates more wealth." Which, if any, of these students are correct? Explain your reasoning. (4 points)

Student A is correct. For full points, the answer must say why A is correct and why B is incorrect.

A is correct because: "Fractional-reserve banking allows banks to create credit in the form of bank deposits, which represent immediate liquidity to depositors. The banks also provide longer-term loans to borrowers, and act as financial intermediaries for those funds." One point for mentioning loans (with an appropriate explanation) and one point for mentioning deposits (with an appropriate explanation).

Student B is incorrect because fractional reserve banking increases the amount of money in the economy, but individuals are no wealthier than they were before. (two points). Making the distinction between "money" and "wealth" should suffice for this section (award full points for doing so)

Award two points if the answer mentions the "creation of money" or "an increase in money supply" or something along those lines but does not offer further explanation. (If they answer with Student B is correct, still award two points if this line of reasoning is followed).

Zero points are awarded for an answer without an explanation.

SET C (15 points)

Consider the payoff matrix below, depicting a game involving two players who can each take one of three actions. Player one can choose between "top," "middle," and "bottom," labeled T, M, and B respectively. Player two can choose between "left," "center," and "right," labeled L, C, and R accordingly. Payoffs are listed in each cell of the matrix, and in each cell, player one's payoff is listed first, followed by player 2.

		Player 2		
		L	C	R
Player 1	T	(7, 6)	(3, 4)	(8, 0)
	M	(3, 2)	(4, 5)	(1, 1)
	B	(3, 4)	(3, 3)	(2, 2)

Find the Nash Equilibria of this game. Do this by following these steps:

A. Consider if player 1 is playing action T. What is player 2's best response? Why is this true? (2 points)

The best response to T is L. (earn 6 over 4 from C or 0 from R)

B. In the same way as above, find player 2's best responses when player 1 chooses M, and do the same for when player 1 chooses B. Explain your thought process. (4 points)

The best response to M is C--earn 5 over 2 from L or 1 from R. The best response to B is L--earn 4 over 3 from C or 2 from R.

C. Now, similarly, find player 1's best response for each of player two's actions: L, C, R. (6 points)

The best response to L is T (7 over 3 from M or B). The best response to C is M (4 over 3 from T or B). The best response to R is T (8 over 1 from M or 2 from B).

D. Use the information above to state the Nash Equilibria of the game. (3 points)

The Nash Equilibria are (T, L) and (M, C). Each is a pair of mutual best responses.

Set D (15 points)

Consider the following economy.

- There are 4000 children, aged 0-16; 6000 young adults, aged 17-30; 4000 adults, aged 31-64, and 5000 senior citizens, aged 65 and up.
- In this economy, 4000 young adults (aged 17-30) currently have a job. Out of the remaining 2000, there are 1000 young adults are currently searching for a job, and the other 1000 are not.
- In addition, out of the 4000 adults aged 31-64, 3000 adults currently have a job. The other 1000 adults are currently searching for a job.
- Finally, 1000 senior citizens currently have a job, and the other 4000 are retired.

A. What is the size of the labor force in this economy? Show your work. (5 points)

5000 young adults + 4000 adults + 1000 senior citizens = 10,000

B. What is the labor force participation rate? Show your work. (5 points)

1000 YA out of labor force + 4000 retired senior citizens = 5000 out of labor force

10,000/15,000 = 66.67%

C. What is the unemployment rate in this economy? Show your work. (5 points)

2,000 actively job searching

2,000/10,000 = 20%

Set E (20 points)

According to the Carbon Tax Center, the United States is one of the few large and industrialized nations on Earth that does not implement a carbon tax. To curtail carbon emission, an alternative to carbon tax (a tax on every square metric of greenhouse gases (GHGs) emission) is a cap-and-trade schema, which is giving every citizen a right to a certain quantity of GHGs emission and allowing them to freely trade that right. Nonetheless, there is a "supply curve" in the carbon market, which shows the cost to environment of a certain amount of GHGs emission, and a demand curve which represents the benefit of companies to emit the gases (so in the market without any regulation the company will emit GHGs until the marginal benefit is 0).

A. Suppose the supply is upward sloping and the demand is downward sloping (with price on the y axis and quantity emitted on the x axis), please draw a graph to illustrate why there is a market failure when there is no carbon tax or carbon cap. (Mark clearly the optimal quantity of emission and the actual quantity). If we know exactly where these two curves are, is there any difference between the two policies in terms of getting the market ? (7 points)

No, since it would be the same whether you impose a tax equal to the marginal benefit of the companies at the equilibrium or impose a total amount of gases allowed to be emitted (and distribute this amount to the population in a form of right) equal to the equilibrium quantity, the market would arrive at the ideal equilibrium. The graph should be a standard supply and demand graph with the actual quantity at the intersection of the demand curve and x-axis, and equilibrium quantity at where the supply and demand curves intersect. Since these two quantities are different, there is a market failure.

B. If we know that the marginal cost of every square metric of GHGs emission is a constant *c* but we don't know anything about the demand curve except that it's a downward sloping curve that goes to 0 at some point, should we implement the carbon tax or cap-and-trade? If you think a carbon tax is better, what should be the tax per square metric of GHGs emission? If you think cap-and-trade is better, what quantity should be the cap for the entire market? (7 points)

You should choose the carbon tax. Since we know the marginal cost of every extra square metric of GHGs is c, we know the y coordinate of the equilibrium should be c. Therefore to arrive at the equilibrium, you need to shift the demand curve up by c regardless where the equilibrium is. To do this you should impose a tax amount of c on each square metric of GHGs. The cap-and-trade strategy is not ideal since we don't know the equilibrium quantity.

C. Now suppose there is actually a certain fixed amount of GHGs emission we know that will bring catastrophe to our world and before that point the marginal cost of every square metric of GHGs is a constant *c* (you can think of this as at that quantity the marginal cost of GHGs emission is infinity) and we know the same information about the demand curve as in Problem B. Does your answer to Problem B change and why? (6 points)

Yes. In light of a known catastrophic amount, it's safer to impose a quantity ceiling, since we don't know for sure whether the supply and demand curve after shifting up the demand curve by *c* will intersect at that deadly quantity or before.

Set F (20 points)

An important principle in financial economics is the Principle of No Arbitrage, which states that there's no opportunity of making money with zero investment. An example would be the pricing of a stock. Since the payoff of a stock when you sell it is always going to be non-negative, the holder has no risk of losing money by holding the stock. The price of buying a stock, therefore, should always be positive. Please apply this principle to the following questions.

A. A call option is a financial derivative that gives you the option of buying a stock at a predetermined strike price K at a fixed future time T (the trader will pay you cash amount equal to the stock price minus the strike price). It's clear that if the stock price at time T is lower than the strike price, you should not exercise the call option to lose money. Please use the Principle of No Arbitrage to explain why the price of a call option will always be positive. (6 points)

We see that the payoff function *f* solely depends on the stock price at time T. If the stock price S is greater than the strike price K, our payoff is S - K. If the stock price is equal to or smaller than the strike price, our payoff is 0 because we will choose not to exercise the option. Since in any circumstances we always have non-negative payoff, by the Principle of No Arbitrage the call option price is positive.

B. A portfolio is a combination of some assets and liabilities. A long position (an asset) is shown by a positive sign and a short position (a liability) is shown by a negative sign. For example, if you buy a share of Stock1 (a long position) and owe someone else a share of Stock2 (a short position), the value P of your portfolio will be P = S1 - S2. Now, if the strike price of a call option of a stock is 0, construct a portfolio consisting of the call option and the stock and use Principle of No Arbitrage to prove that the price of this call option will be exactly the current stock price. (6 points)

Consider the portfolio with a long position on one share of the stock and a short position of the call option. At time T, we should always exercise the option since the stock price can never fall under 0, and by exercising we will always have the payoff S, with which

you can buy one share to pay off your short position. Since this is true for all stock price, by the Principle of No Arbitrage, we know that the option price must be higher or equal to the initial stock price. If we reverse the positions, we can prove similarly that the option price must be lower or equal to the initial stock price. Hence they are equal.

C. A put option is a financial derivative that gives you the option of selling a stock at a predetermined strike price K at a fixed future time T (the trader will pay you cash amount equal to the strike price minus the stock price). In contrast to a call option, this time you won't exercise the put option if the strike price is lower than the stock price. Suppose that there is no interest rate and no inflation in the market (so a cash amount of K now is the same as a cash amount of K in any future time), use the Principle of No Arbitrage to derive the difference between the price of a call option and a put option on the same stock with the same strike price K (this is often called the put-call parity). (Hint: it might be helpful to draw the graph of a call option and a put option with the payoff on the y-axis and stock price at exercise time on the x-axis) (8 points)

The price for put option is (K - S)+ and the price for call option is (S - K)+, if you subtract put from call you get K - S, which is the difference. ((X)+ means the positive part of X, which equals to X if X is greater or equal to 0, and 0 if X is smaller than 0)