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Game Theory: An unorthodox take on Prisoner's Dilemma

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Abstract -

This paper discusses the basic Prisoner's Dilemma and focusses on the analysis of each outcome. The paper also highlights Iterative Prisoner's Dilemma and explains the same to the readers. The main intention of the paper is to focus on a particular outcome and present theories and logic to subscribe to the premise. There are multiple arguments that can be made with regards to how the game is played and outcomes are perceived. The paper analyzes each of those arguments and compares them to come up with a point to prove the argument that was made. The paper does this by giving multiple examples.

The paper utilizes tools from Philosophical Decision Theory to present arguments for defaulting position and analyzes the arguments to show that the position of cooperation is weakly preferred. The paper uses Regret principle to show how the different arguments of both the positions stack up against each other and then comes to a conclusion of defaulting.

Key Words:

Game Theory, Prisoner's Dilemma, Philosophy, Ethics, Tragedy of Commons, Management

1.INTRODUCTION

The Prisoner's Dilemma is a concept used to model a strategic interaction in which actors choosing their behaviors rationally according to their own self-interest make everyone worse off than they could have been otherwise. This particular "game" is used both to understand failures of cooperation such as arms races and ethnic warfare and to prescribe particular solutions designed to elicit cooperation. The key feature of the game is that, when the game is played only once, no matter what another player does (cooperating with me or trying to exploit me), I am better off trying to exploit the other player – so in the end, every player exploits rather than cooperates, and they are all worse off than they would have been could someone have "forced" them to cooperate. This is the beauty of Prisoner's Dilemma where in defaulting is preferred over cooperation. The paper examines this in detail over the next paragraphs.

Prisoner's Dilemma is an example of a game analyzed in game theory showing how two random individuals might not cooperate, even if it appears that it is in their best interests to do so. It was originally framed by Merrill Ford and Melvin Dresher. The game is set as: two prisoners are arrested and imprisoned. They are kept in a solitary confinement with no means of communicating with the other. The prosecutors don't have enough evidence to convict the pair. Hence, they give them a situation which will help the prosecutors to get enough evidence to convict the pair or at least one of them. The situation is like this:

	Confess – B	Don't Confess - B
Confess -A	-10, -10	-1, -20
Don't Confess - A	-20, -1	-2, -2

More precisely put the situation is like this, if both of them confesses they get 10 years each. If one of them confesses, the other gets 10 years and the confessor gets one year. But if no one confesses they get two years each for their other offenses.

Now, let's look at the matrix from A's point of view. A can choose between confessing or denying the charges. There are four different outcomes for A depending on what either of the prisoners do. If A knows that B will confess then it's better for A to confess as well, because if A decides not to confess and B confesses then A gets 20 years of prison whereas if A confesses given B is confessing, A gets 10 years of prison. Now, let's say that A knows B will not confess, so A can either confess or he cannot. The choice is between 1 year in prison vs 2 years in prison. In this case also, rationally, confessing is better for A as compared to not confessing, given B is Not Confessing. So, in either case it's better for A to confess.

Now, let's look at the matrix from B's point of view. B can choose between confessing or denying the charges. There are four different outcomes for B depending on what either of the prisoners does. The outcome for B is different depending what A decides to do. In one case B has to make a choice between 10 years in prison or 20 years in prison. And the other is between 1 year in prison or 2. The choices B gets is similar to what A gets. Hence in either situation as seen in the A's condition, confessing is better than Not Confessing. So, B will also end up confessing and both will get 10 years in prison, versus the potential opportunity to get just 2 years in prison.

It is implied that the prisoners will have no opportunity to reward or punish their partner other than the prison sentences they get and that their decision will not affect their reputation in the future. Because confessing offers a greater

reward than cooperating with them, all purely rational self-interested prisoners will confess, meaning the only possible outcome for two purely rational prisoners is for them to confess. The interesting part of this result is that pursuing individual reward logically leads both of the prisoners to confess when they would get a better reward if they both kept silent. The paper will attempt to analyze this case and present arguments on both the positions and conclude points to prefer one position over the other.

If the outcome is purely to be kept in mind and somehow the prisoners got into agreement that they won't confess, it'd seems to be the preferable outcome as both get just two years in prison. Both the prisoners have to trust each other,

and both have to see the greater good for themselves. By not confessing, both of them, they definitely can reduce their sentences from 10 years to 2 years. Of course, the next immediate thought is to betray their partner. But one thing to understand here is the same option is also available to the other prisoner and he can too betray. Hence, rather than betraying the other prisoner, one should trust the agreement and not confess.

The prisoner's dilemma shows that what is optimal for one might not be for the group. People often put their self-interest before the group interest. Individual rationality sometimes come into conflict with group rationality. In this game, rationality forces each player to choose an outcome that is worse than the best outcome. Hence, if the players think more about the group outcome, each of them might end up with better results. And this is true not just for this specific case but for all the cases in numerous real-life examples.

2. REAL WORLD FAILURES OF NON_COOPERATION

The notorious 'free rider' problem is an example of a Prisoner's Dilemma involving many individuals. Consider the bus systems in many European countries. They are paid for by what is almost an honor system of passengers paying their fares. The busses can only be kept running if enough people pay the fare, but not everyone needs to pay the fare to keep the busses running. If I think from a passenger's POV – they shouldn't want to pay and would hope that orhers pay such that the service continues. But if everyone adopts this strategy, the buses will no longer run and everyone will have to take taxis, or buy a car which are worse situations for everyone than if everyone paid the fare.

A similar example as above is encountered in one of the courses at Eller. As part of the coursework, students are required to provide feedback to the professor at the end of the courses. Some professors will offer some bonus points to the entire class if 75% of the class strength provided the feedback. Now, 25% of the students can earn these bonus points without providing any feedback. So, if all the students start thinking that they will not fill the survey as others are doing it and they can just get free bonus points and if enough students think so, that might result in no one earning these free bonus points. In this case as it turns out to be cooperating is better than defecting.

2.1 Symmetric 2x2 Prisoner's Dilemma with Ordinal Payoffs

A prisoner's dilemma game can be defined in the following matrix:

	C	D
C	Z, Z	X, Y
D	Y, X	W, W

Where – Y>Z>W>X

There are two players, Row and Column. Each has two possible moves, "cooperate" - C or "defect," - D corresponding, respectively, to the options of remaining silent or confessing in the illustrative anecdote above. For each possible pair of moves, the payoffs to Row and Column (in that order) are listed in the appropriate cell. ZZ is the "reward" payoff that each player receives if both cooperate. WW is the "punishment" that each receives if both defects. YY is the "temptation" that each receives as sole defector and XX is the "sucker" payoff that each receives as sole cooperator. We assume here that the game is symmetric, i.e., that the payoff is the same for each player, and payoffs have only ordinal significance, i.e., they indicate whether one payoff is better than another, but tell us nothing about how much better. It is now easy to see that we have the structure of a dilemma like the one in the story. Suppose Column cooperates. Then Row gets ZZ for cooperating and YY for defecting, and so is better off defecting. Suppose Column defects. Then Row gets XX for cooperating and WW for defecting, and so is again better off defecting. The move DD for Row is said to strictly dominate the move CC: whatever Column does, Row is better off choosing DD than CC. By symmetry DD also strictly dominates CC for Column. Thus two "rational" players will defect and receive a payoff of WW, while two "irrational" players can cooperate and receive greater payoff ZZ. In standard treatments, game theory assumes rationality and common knowledge. Each player is analytical, knows the other is too, knows that the other knows he is rational, etc. and the players are aware that all the players value the outcome. But since DD strictly dominates CC for both players, the argument for dilemma here requires only that each player knows his own payoffs. It is also worth noting that the outcome (D,D)(D,D) of both players defecting is the game's only strong Nash equilibrium, i.e., it is the only outcome from which each player could only do worse by unilaterally changing its move. Flood and Dresher's interest in their dilemma seems to have stemmed from their view that it provided a counterexample to the claim that the Nash equilibria of a game constitute its natural "solutions". Hence,

in this situation also, where the payoff is ordinal, prisoners are better off with defaulting.

3. TRAGEDY OF COMMONS

"Each member of a group of neighboring farmers prefers to allow his cow to graze on the commons, rather than keeping it on his own inadequate land, but the commons will be rendered unsuitable for grazing if it is used by more than some threshold number use it." The tragedy of the commons is a term used in social science to describe a situation in a shared-resource system where individuals act according to their own self-interest behave anti-ethically to the common good of all other people by plummeting the common resource which is available to all and could be there forever, through their collective actions.

Take this example - Every fisherman knows that if there is too much fishing then eventually fish stocks will run out. If all the fishermen could agree to fish at sustainable levels, then the fish stocks could last forever. However, if one fisherman starts to act selfishly and starts to overfish then eventually the fish stocks will run out. And when other fishermen see this, they will also start to over fish. It just starts with someone acting selfishly and then the other follow suit. The first person might start because they think that just them overfishing will not make any difference but once they start then everyone else soon joins them and the stocks run out.

This is similar to the prisoners' dilemma. However, in the prisoners' dilemma individuals cannot communicate and so, if they act logically, then they won't co-operate with the other players and will end up with a worse outcome. In

the tragedy of the commons where all the players can communicate to each other and make a common ethical choice to save and harvest the common resource but still end-up overusing the common resource. The concept of Tragedy of Commons can be paralleled with Prisoner's Dilemma, where each prisoner acts on his best self-interest and ultimately gets only second to best outcome. If the involved individuals start acting or behaving in a manner that is thoughtful of the other players involved everyone can benefit more than they would otherwise.

4. ITERATIVE PRISONER'S DILEMMA

So far, the paper discussed what happens when the PD is played once. But what if it's played multiple times by the same players? Now, let's say the players are made aware of the number of iterations the game will be played, mutual cooperation will be unstable. But if the players don't know which or when is the last round, things become interesting, under such conditions, cooperative strategies work well.

A particularly effective (and simple) strategy is tit-for-tat, in which the player cooperates in the first round, and from there on the player does what the other player did in the previous round. This punishes defection with immediate but short-lived consequences—"you just defected, so now I'm denying you the benefits of my cooperation. But I'll cooperate if you cooperate." In The Evolution of Cooperation, Robert Axelrod says of tit-for-tat, "[w]hat accounts for [its] robust success is its combination of being nice, retaliatory, forgiving, and clear."[3]it's a great strategy if zoomed-out and viewed – it starts with trust, avoiding trouble. As soon as it detects defection, the system repays in a similar fashion and eventually rewards as soon as the system detects cooperation. And it's easy to recognize and understand.

The point to note here is tit-for-tat is one of the many available and possible "nice strategy". In iterative Prisoner's Dilemma, strategies that are nice and cordial tend to deliver reasonable outcomes as compared to strategies that might hurt the others. The lesson: be cooperative until the other player defects, and then react but forgive. Think long-term and gain trust. An important feature accounting for tit for tat's effectiveness is its niceness, where an individual should never first defect and come out as non-trust worthy player. Tit for tat is also effective because it is retaliatory: The player who betrays first and shows sign of defection is also treated with the same gesture. It gives the other player an opportunity to repay back the same flavor of non-cooperative behavior. Additionally, this strategy is also forgiving, such that when the player that behaved in a non-cooperative way gets the same reciprocation, they get a chance to change their behavior and regain the trust. As soon as the other player sees that the first player has started cooperating it gives them some hope and they reciprocate in cooperating mode. Finally, tit for tat is also a clear strategy, readily understood by others, and the final goal of it is to establish trust and cooperation.

One important concept to discuss here is if the game is a limited iteration game then the players will rush to default. Let's say it's a 'n' iteration Prisoner's Dilemma game. Player A knows that player B will default in the nth game, so the player might try to default in 'n – 1'th game. And this information is available to Player B who in turn will try to default at 'n – 2'th game and so on. Ultimately, the players will turn to defaulting in the very first game. It becomes almost similar to centipede games. And turns out to be that defaulting is the optimal strategy to beat the other person

to it and ensure that the outcome is not the worst one. Similarly, in the infinite repetitive Prisoner's Dilemma game, defaulting is sought whenever it's known that the particular game is the last game or whenever the other player starts defaulting. For the purpose of this paper the focus will be on single shot Prisoner's Dilemma. The iterative model was introduced just to give sense to what would happen in the long run and if it's any different, the final outcome, from the single-shot Prisoner's Dilemma.

5. PROPOSITION

The concepts defined and discussed above will be used in the latter part of the paper to discuss more examples and case studies on Prisoner's Dilemma. I personally believe in confessing is the best strategy even though it's not the best outcome from the given available outcomes. In the below paragraphs the paper will try to put up the proposition and discuss why confessing is the best argument and 'Not Confessing' is not. The paper will cite multiple examples to prove the argument. First of many examples is –

There are two firms in the market, A and B. Both the firms are operating with equal market share. One day firm A comes up with a strategy to reduce the prices of their product and also invests on advertising to market their new strategy of reduced pricing. If A only continues with this strategy, it would benefit and would substantially increase revenue and its market share. But if B also follows the suit and decreases the price and invests in marketing the same strategy, it would be able to retain their customers and revenue. Since, both the firms exploit the reduced pricing strategy they ultimately retain their market share and may or may not have the same revenue. But, on the other hand if both the firms stick to their original plan, they will continue to make profits. And the last strategy is the optimal strategy for the firms and it works on the group rationality reasoning.

The problem with group rationality in this approach is, companies tend to work on maximizing their own profitability and are least concerned about the other. In fact, they would like for other firm to be second to them and take their market share. Hence, someone will always default and try to gain more revenue and market share. Hence, the optimal group strategy is not always good for the individual. It is really hard in the real life to get to a common ground that is really good for everyone. Someone somewhere will always have this thought and it is safe to assume that everyone will have this thought to maximize their profitability and act as a rational individual. The act of individual rationality when made by everyone else involved in the same act results in 'Tragedy of commons' and as a result of which everyone involved gets hit by some point, maybe some ordinal value as an absolute value is hard to be given to this outcome. It's very common in all kind of business and organizations tend to act in this manner.

	Reduce Price & Promote Firm - A	Don't reduce Price & don't promote Firm - A
Reduce Price & Promote Firm - B	Revenue (may) decrease and same market share	Firm B gains Revenue & Market share
Don't reduce Price & don't promote Firm - B	Firm A gains Revenue & Market share	Same revenue and market share as before

It's evident from the above matrix that colluding and coming to agreement is better but it's hard to retain the same agreement for the longest period of time. For the longest time in my life I believed that Apple is an organization that doesn't follow the rules of the game and doesn't follow the suit. It sets the rules and plays it alone. Apple products were considered premium (are also considered premium now) not only because of pricing but also because of the service they provided. Apple never went into a price war or reduced their price of the products. Apple never gave any discounts in any holiday or mass shopping events. I always wondered what made them do so and how are they able to sustain for this long without heading in the direction where other firms were headed. I was really amazed. Prisoner's Dilemma or other decision theory paradoxes are also game theory strategies that many firms deploy. Some firms have been successful in their strategy and have changed the game. Philosophically, we might see something as a paradox whereas in real life it might just be a rational choice based on one's profit and future vision. But until now, this time when Apple released their new phones, they were in for a shock. Their pricing strategy didn't work out. Apple thought that they have been the master of the game and can continue to be so. And were very confident when they launched the new models in September of this year only to learn the hard way that they cannot continue to avoid the market. With every year iteration Apple discontinue the previous year's model and they followed the same strategy this year too. But after seeing the sales of this year iphones, Apple has to change their decision and has started production of the previous model (Iphone X). Basically, this is as good as reducing the price of the iPhone because users are not ready to buy the costlier model. In a latest update, Apple has reduced the price of their phones in the Japanese market

The above example also proves the strategy of cooperating and/or confessing. To survive and not be in a position to get surprised one must be ready to adopt to the environment and make a rational decision. Many sectors of the economy have two main rivals. In the U.S., for example, the fierce rivalry between Coca-Cola and PepsiCo in soft drinks, and Home Depot versus Lowe's in building supplies, has given rise to numerous case studies in business schools. Other fierce rivalries include Starbucks versus Tim Horton's in Canada, and Apple versus Samsung in the global mobile phone sector.

The proposition to defect is a better proposition because there is no legal binding to anyone to hold their end of the bargain. Anyone, any organization can defect at any given point and the cost will be left to bore by the other party involved in the dilemma. Cooperation is a trust game and trust is very costly in real world. Two strangers cooperating and trusting each other is not normal. Organizations are competitors and cooperation will only come into play when that is the only best strategy. Organizations always try to outplay and outsmart their competitors. In above examples,

cooperating wasn't the best strategy all the time. If Firm A knows that the other firm B will cooperate, then it makes sense financially and strategically to defect and get the market share and more revenue. Firm B will follow the suit and the industry will shift to the new normal. It might take time, but the price war will end and the organizations will shift to a new normal where the prices will be stable, market share will be stable and organizations will try something else to gain the next wave of market share. Unless there is a legal agreement it is nearly impossible for firms to cooperate. Cooperation will happen when the other options yield loss or not the equal number of gains.

Researchers often use the single-trial Prisoner's Dilemma when they want to study how people approach one another in the absence of a history of interaction and in the absence of a future of interaction. Hence, these choices are not influenced by considerations regarding the past (e.g., retaliation) or the future (e.g., adopting a strategy to obtain cooperation). In these situations, intuition of the other play a very important role. Any information that is relevant to one's expectations about the other's possible choice is useful, at least when one's own choice depends on what the other is going to do. For example, people expect much more cooperation from another person who is perceived as honest than from another who is perceived as dishonest. Also, people may also derive expectations from stereotypical information.

5. REGRET IN PRISONER"S DILEMMA

Regret has a very important role in everyone's life, the things people do, the way people act, the way people make decisions and evaluate their options. Regret makes the beings do things that otherwise some might not do it at all. Regret is a feeling of sadness, repentance, or disappointment over something that's happened or been done… especially a loss or missed opportunity. Regret is not just a simple emotion, the way the definition above implies. It also involves what philosophers call a conditional intent: If I had it to do over, I would do things differently. Problem is, that leads to a paradox. Decision analysts feel that the axioms are so logical and reasonable that the situations in which the decision makers violate the axioms are 'paradoxes'.

There is something called symmetric regret. Not all decision problems yield a symmetric regret outcome. To put things in perspective here is an example – A farmer has a crop whose value at harvest time, two months from now is uncertain. He is getting an offer now from a businessman for his crop at a fixed price per bushel of the grain that will be produced at the harvest. Whatever maybe the market condition irrespective of that, the businessman is ready to offer the farmer a fixed per bushel price for the grain. To simplify the example, the price per bushel of grain at the time of the harvest will be either $5 or $9 with equal probability. The current offer from the businessman that farmer will receive is $7 per bushel of grain. This offer is irrespective of any conditions and it will not change at the time of the harvest. Now we know the quantitative value of the grain per bushel at the time of harvest. The maximum worth it can attain and the minimum. The current offer is fixed and doesn't have to do with any market condition. A traditional decision analysis show that the fixed price offer from the businessman has no risk and guarantees money whereas waiting does have risks. It can either make the farmer richer than the current offer or poorer, depending upon the market condition.

The farmer has a decision to make. It's difficult for him to predict the price and at the same time he doesn't want to do something that makes him regret latter. How will the farmer make a rational decision? What tools can he use to make decision? If the farmer sells the grains right now to the business man at $7 per bushel of grain and the price of the grain at the time of the harvest becomes $9 then the farmer will regret for the $2 loss. On the other hand, if the farmer sells the crops now to the business man at $7 per bushel of grain and the price of the grain at the time of the harvest becomes $5 then the farmer will be happy that he saved himself a loss of $2 per bushel of grain. The other condition where the farmer doesn't sell the crops to the business man now. At the time of the harvest is $9, the farmer will be happy that he took the right decision. If the price at the time of the harvest is $5, then the farmer will regret that why he didn't sell off the grains when he had the offer from the business man. So, either side of the decision he has a regret value of $2. Hence, this is symmetrical regret condition, which it makes it even harder to solve. But not all problems in decision theory are symmetrical.

Regret is not often used by the decision theorists to solve a problem. But if it is used in the problems then most of the problems can be made simpler and aid the decision makers to come to a conclusion faster and efficiently. Let's take up the prisoner's dilemma problem and apply regret function to it and see if we can get to a solution faster and also let's try to prove the overall stand of 'defaulting'.

	Confess B	Don't Confess B
Confess A	-10, - 10	-1, -20
Don't Confess A	-20, -1	-2, -2

Let's assign a regret value to each of the option.

	Confess B	Don't Confess B
Confess A	a1, b1	a3, b2
Don't Confess A	a2, b3	a4, b4

For A –

a2 > a1 > a4 > a3

And for B –

b2 > b1 > b4 > b3

As mentioned above, the regret value for A is the highest when it gets 20 years in prison. It's second highest when it gets 10 years in prison, third highest when it gets 2 years in prison and least when it gets 1 year in prison. Similarly, for B the regret value is the highest when it gets 20 years in prison. It's second highest when it gets 10 years in prison, third highest when it gets 2 years in prison and least when it gets 1 year in prison. The least regret value comes when the individual gets the minimum prison sentence. And how does that happen? It happens via betraying the other prisoner. But the striking thing to notice here is the ordinal value or philosophical value of this regret which is a feeling, is same for both the prisoners. If we can compound this affect with the other prisoner's sentence which is way lower than that of the prisoner who cooperated, the regret feeling gets exponentially compounded. This feeling of regret is too much to be comprehended by just writing here or discussing it. This option of betraying to each other is same and available to both. If for once a prisoner gets betrayed and he gets the same option again, he will never again cooperate and will default always. The time to spend in prison is too much and something to analyze here is, the prison who even thinks of cooperating doesn't get anything by doing so. There will always be a chance that the other prisoner might default. This chance, however low it might be will always create a sense of regret which will be higher than the chance of the other prisoner not defaulting. Let's say that the chance that Prisoner A will default is 0.3. so, the chance that the prisoner A will cooperate is 0.7. And this information is available to Prisoner B. the probability of Prisoner A defaulting is enough to induce a sense of regret in the Prisoner B. And this regret will be more than 0.7 when induced in the prisoner B. This is how the prisoner B should think and default.

Going by above logic and explanation it seems rational for prisoner to betray. And both the prisoners will think alike, because the information available to both of them is same. There is no extra information available to either of the prisoners. For them to behave and think alike is not a surprise. This eliminates the least regretful option. The next one is to cooperate. If both of them cooperate, they get the second least regret value. But that is the catch, it's the second least regret value. Once the prisoners agree to cooperate and are certain that the other will cooperate, one will try to betray and get to the least regret value. But again, the same information is available to the other as well and the other will also think to betray and ensure that his regret value is the least. Again, if one keeps his end of the deal and doesn't default whereas the other betrays and get his regret to the least value, the one who cooperated will never ever cooperate if given the same option is presented again (can be thought of iterated Prisoner's Dilemma). And if the same is repeated with different pairs of prisoners, cooperating might not be easy and simple in the long run for limited repetitive game or one time game. This logic also entails to defaulting.

As described above, the second-least regret option is also ruled out. This brings the third option, i.e. 10 years in prison for each of the prisoners. And this seems to be the most optimal outcome for both the prisoners. Given all the logic and information, no one could have one better. Because without an external agreement it's very hard for prisoners to ensure that the other will keep their end of the bargain. Defaulting ensures that the prisoner will get a maximum of 10 years of prison which is much better than 20. If the prisoner is not defaulting, then there is a constant fear of the other person. The dependency on someone else makes it even harder and the regret value shoots up. To minimize one's regret and maximize the unsaid utility, prisoner should default.

Now the paper will examine how regret plays out in the second example discussed in detail above.

	Reduce Price & Promote Firm - A	Don't reduce Price & don't promote Firm - A
Reduce Price & Promote Firm - B	Revenue (may) decrease and same market share	Firm B gains Revenue & Market share
Don't reduce Price & don't promote Firm - B	Firm A gains Revenue & Market share	Same revenue and market share as before

Applying regret function to the matrix:

	Reduce Price & Promote Firm - A	Don't reduce Price & don't promote Firm - A
Reduce Price & Promote Firm - B	a1, b1	a3, b2
Don't reduce Price & don't promote Firm - B	a2, b3	a4, b4

For A – a3 > a1 > a4 > a2

For B – b3 > b1 > b4 > b2

As mentioned above, the regret value for A is highest when its revenue decreases along with the market share. This situation happens when A doesn't default and cooperate but B defaults and doesn't cooperate. The regret is second highest when the revenue decreases but the market share remains the same. Even though the regret seems to be high but in the subsequent paragraph it will be shown that the firm is better off defaulting. Regret is third highest when the firm A doesn't default and cooperates and the revenue & market share remains the same and least when firm A gets more Revenue and market share. Similarly, for B highest

when its revenue decreases along with the market share. This situation happens when B doesn't default and cooperate but A defaults and doesn't cooperate. The regret is second highest when the revenue decreases but the market share remains the same. Even though the regret seems to be high but in the subsequent paragraph it will be shown that the firm is better off defaulting. Regret is third highest when the firm B doesn't default and cooperates, and the revenue & market share remains the same and least when firm B gets more Revenue and market share. The least regret value comes when the individual gets the maximum benefit as compared to the other firm. And how does that happen? It happens via betraying the other firm. But the striking thing to notice here is the ordinal value or philosophical value of this regret which is a feeling, is same for both the firms. If we can compound this affect with the other firm's benefit which is way higher than that of the firm that cooperated, the regret feeling gets exponentially compounded. This feeling of regret is too much to be comprehended by just writing here or discussing it. This option of betraying to each other is same and available to both. If for once a firm gets betrayed and it gets the same option again, that firm will never again cooperate and will default always. The loss of revenue is too much, companies and go bankrupt, share prices might plummet, their customers might leave them, and multitude of other things might happen. There will always be a probability that the other firm might default. This chance, however low it might be will always create a sense of regret which will be higher than the probability of the other firm not defaulting. Let's say that the chance that Firm A will default is 0.3. so, the chance that the firm A will cooperate is 0.7. And this information is available to Firm B. The probability of firm A defaulting is enough to induce a sense of regret in the firm B. And this regret will be more than 0.7 when induced in the firm B. This is how the firm B should think and default.

Going by above logic and explanation it seems rational for firms to betray. And both the firms will think alike, because the information available to both of them is same. There is no extra information available to either of the firms. For them to behave and think alike is not a surprise. This eliminates the least regretful option. The next one is to cooperate. If both of them cooperate, they get the second least regret value. But that is the catch, it's the second least regret value. Once the firms agree to cooperate and are certain that the other will cooperate and not default, one will try to betray and get to the least regret value. But again, the same information is available to the other firm as well and the other firm will also think alike with the same available information and try to betray and ensure that its regret value is the least. Again, if one keeps its end of the deal and doesn't default whereas the other betrays and get the regret value to the least value, the one who cooperated will never ever cooperate again if given the same option in the future. And if the same game is repeated with different pairs of firms, cooperating might not be easy and simple in the long run for limited repetitive game or one-time games. This logic also entails to defaulting.

As described above, the second-least regret option is also ruled out. This brings the third option, i.e. same market share for both the firms and revenue might remain the same or decrease a bit because of lowering the prices of their offerings. But the revenue might also remain the same because the firms might get more sales because of lower prices and possibly more revenue. This option as it is turns out to be the most optimal outcome for both the firms. Given all the logic and information, no one could have done better. Because without an external agreement it's very hard for firms to ensure that the other will keep their end of the bargain. Reducing the price of their offerings ensures that the firms will retain the same market share, their customers will be with them, they will have a company to run. If the firm is not lowering their price, then there is a constant fear of the other firm's strategy. The dependency on someone else makes it even harder and the regret value shoots up. To minimize one's regret and maximize the unsaid utility, firms should default.

6. CONCLUSION

Utility theory is often criticized because it fails to predict actual behavior for some straightforward comparisons among alternatives with uncertain consequences. It is quite evident and easy to understand why decision makers may be skeptical of expected utility analysis as a predictive tool when it apparently fails even for some simple comparisons. The analyst's only defense of the theory has ben to offer a careful explanation of why certain of the decision maker's responses are not aligned with the axioms. This explanation usually leaves the decision maker unimpressed. This paper shows that some of the paradoxical behavior of decision makers is consistent with a desire to avoid post decision regret.

Regret is very important feeling and philosophically if thought about it in retrospect it creates a feeling that is not desired. Regret comes after the being has taken a decision and has received the output. The output received isn't the desired outcome of the action performed by the being and this causes to produce a feeling of regret in the being. Philosophically it impacts the being the most and all the future actions taken by the being, regret has a very important role to play in it. As seen in the above examples, even though the best outcomes were something lese and ideally most desirable outcome but the fear of regret, the feeling that the beings are not comfortable with made the beings to act in a way that will minimize their regret. And if seen in retrospect, minimizing regret was the best way to think about it. Regret is a very powerful tool in Decision Theory and to some extent is practical too. It can change the course of one's decision making approach. The paper analyzes many examples and shows how regret plays an

important role in decision making. What is one's objective outcome when regret is applied versus when it is not. Regret makes decision makers more rational and pragmatic. It makes the decision makers to think about all the outcomes philosophically and not just objectively. Philosophy has a deep relation with decision making. People get influenced too much by objectivity of the outcomes and tend to neglect rational philosophical decision theory that has a vital influence on the decision-making process and how beings feel after the outcome.

Prisoner's Dilemma one such game that has many outcomes and the outcomes change depending on the other person's choice. Just think about the beauty of the game – even though the decision one makes is independent, but the outcome has an influence of the decision made by the other person. It's a beautiful game. Anyone involved in the game wants his outcome to be maximized. But to maximize one's outcome it has to be in sync with the other person's decision. It gives a sense of collaboration and communication. And again, the game is beautiful because even after collaboration and communication it's seen that people aren't able to maximize their outcome. Cooperation without accountability is a big ask from any being. And it's very practical as shown in the paper. The two examples discussed in the paper shows how the prisoners and the firms will perform with and without collaboration depending upon how the other prisoner or firm performs. Whenever the prisoner would think to cooperate the very immediate thought would be—what if the other prisoner doesn't cooperate and defaults? The entire prison time on oneself is a long time that the prisoner has to go through. More than this, the thought of other prisoner defaulting, will make prisoner A's thought process to lean towards defaulting. And when analyzing all the options available, outcomes of each option, it turns out that defaulting is better than anything else. The paper proves the point that both the prisoners are better of if they default. It's seen that without any external agreement it's very hard for any one of them to trust the other and not default. The price to pay for not defaulting is too high. The paper analyzes a second example where two firms competing with each other in a market for higher market share and revenue. The firms can continue to price the same and retain everything as it is. But that's very risky. Because technologies evolve, market evolve, customers evolve, and anyone can access a market from anywhere. Any new firm can enter any new market and disrupt it. All these are feasible examples. And the regret involved with any of these happening and the firm losses out because it was too busy playing the part of cooperation will be too high. Not to forget the objective loss will be higher too. With this example, the paper picked up the prisoner's dilemma game and applied to a real-life scenario. It's clear that cooperating even though can be better but in the long run, firms were better off by defaulting or in this case reducing the price of their products and/or offerings.

Hence, the paper successfully analyzed and presented the points to showcase how defaulting is better in Prisoner's Dilemma.

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