Jakub Puciato[1], Magdalena Danek[2]

A Game-theoretic Explanation for the Emergence of the Second-order Rule of Justice Pacta Sunt Servanda

Streszczenie

W niniejszym artykule badaniu poddano warunki wykształcenia się reguły drugiego poziomu *pacta sunt servanda* na gruncie teorii gier. Gra dylemat więźnia może być skutecznie wykorzystywana do analizy zachowań uczestników grupy w celu badania warunków ich kooperacji i regularności w tym względzie. Reguła *pacta sunt servanda* jest przyjmowana spontanicznie przez członków tych grup, które charakteryzują się określonymi cechami. Po pierwsze, muszą zachodzić ciągłe (a nie sporadyczne) interakcje między członkami grupy. Po drugie, członkowie grupy wybierają strategie typu TFT (*Tit-For-Tat*), jako że są one najbardziej efektywne w przypadku powtarzalnych interakcji. Po trzecie, można wyróżnić sankcję wymierzaną za uchybienia normie *pacta sunt servanda*. Norma ta jest internalizowana przez członków grupy jako konwencja, która służy ulepszeniu suboptymalnego *equilibrium* Nasha do sytuacji optymalnej w sensie Pareto. Odpowiednikiem sankcji w dylemacie więźnia będzie odwet gracza za nawet incydentalną zdradę oponenta. Po czwarte, wymaganie powtarzalności dylematu więźnia podkreśla potrzebę wykształcenia się zaufania między uczestnikami. Warunki takie, odpowiednie dla wykształcenia się reguły *pacta sunt servanda*, będą występować w grupach małych i spójnych, o stałym członkostwie, cechujących się występowaniem wzajemnych zależności między uczestnikami.

[1] Student V roku prawa na Uniwersytecie Jagiellońskim.
[2] Absolwentka Uniwersytetu Jagiellońskiego.

Summary

The herein research investigates the conditions for emergence of the second-order rule of justice *pacta sunt servanda* in a game theory. The prisoner's dilemma game can be effectively used in an analysis of the behaviour of the group members to establish the conditions of their co-operation and its regularity. *Pacta sunt servanda* rule would emerge spontaneously among the members of those groups that are characterised by certain requirements. Firstly, there are continuous (not occasional) interactions between group members. Secondly, group members choose a TFT strategy or its variants, as these are the most effective strategies in the case of iterated interactions. Thirdly, a sanction for incompliance with *pacta sunt servanda* norm can be distinguished. This norm is internalised by group members as a convention, which facilitates the refinement of a sub-optimal Nash equilibrium to a Pareto-optimal situation. The sanction corresponds to a retaliation of a player for even an incidental defection in a prisoner's dilemma. Finally, the necessary repetition of the prisoner's dilemma emphasises the importance of establishing trust between group members. These conditions, adequate for emergence of *pacta sunt servanda* rule, are characteristic to small, coherent, interdependent groups, with a stable membership.

I. Introduction

The aim of this paper is to present an explanation of the phenomenon of spontaneous cooperative behaviour of two active agents, and using the tools and notions in game theory while doing so. The aforementioned situation is characteristic of contractual relations, where two parties choose to fulfil their obligations without the prior knowledge whether the other party will honour the contract as well. Therefore, the cooperation in question is a behaviour that must be looked at not only to explain the rationale of entering into contractual obligations, but also to investigate the conformity to the rule of *pacta sunt servanda*. This second-order rule of justice describes positive and negative aspects of obligations of both parties. Our game theoretical analysis will show that *pacta sunt servanda* rule may spontaneously emerge between a specific type of rational players during continuous interactions between them. Such a rule may be characterised best by the notion of convention which encourages rational players to cooperate and, at the same time, protect themselves from any form of exploitation from defectors.

In game theory, the contractual situation could be described best by the prisoner's dilemma game in which the Nash equilibrium outcome is not a Pareto-optimal outcome. In a single, i.e. non-iterated, game, game-theoretically rational players will never choose a much more profitable cooperation leading to a much more profitable payoffs, but would not rather choose cooperation or defection, scared that the only one-sided attempt to establish a cooperation between them may lead to even worse results. However, in this paper it will be shown that cooperation will emerge spontaneously between players if their interactions will be prolonged and, therefore, will continue.

Additionally, the following analysis is aimed at establishing the requirements of such cooperation that must be met for it to become a constant and enduring characteristic of players' interactions. In accordance with the notion of rationality of *homo oeconomicus*, rational players maximise their own utility payoffs, but do not act altruistically and spontaneously. However, by choosing a specific type of strategy that fulfils the requirements in question, agents that are *homines oeconomici* can act in a way that not only maximises their payoffs but also does not inhibit the payoffs of their opponents. We argue that the Tit-For-Tat strategy provides for such a strategy. This analysis will show that this particular means can transform an iterated prisoner's dilemma game into a pure coordinating game, the Stag hunt game, in which the rule *pacta sunt servanda* that would emerge spontaneously as a convention, serves as a refinement of a Nash equilibrium[3].

II. The Prisoner's Dilemma

A prisoner's dilemma game is a game characterised by the following order of preferable outcomes: T > R > P > S and R > (T+S)/2.

Table 1. Prisoner's dilemma with abstract values of players' preferences and an exemplary one

P1/P2	C	D
C	R,R	T,S
D	S,T	P,P

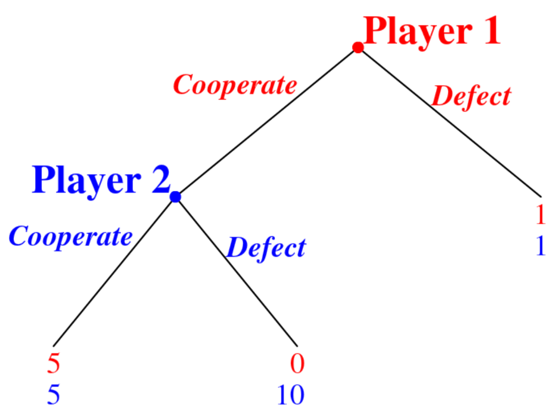
P1/P2	C	D
C	5,5	6,0
D	0,6	1,1

This dilemma can also be presented as a bargaining problem. Player 1 wants to sell a commodity that has a marginal utility of 1 for him/her and 5 for Player 2. Player 2 wants to buy it from Player 1 for the amount of money of 5 which has a marginal utility of 1 to him/her, as it has already been said. If they fulfil their contractual obligation, they will both enjoy an increase in their marginal utility up to 5. If they both defect, their money or their commodity will remain unchanged. If one of them defects while the other one follows a contractual obligation, one of the players will have everything while the other

[3] See further *infra* note 21.

one will be left with nothing. As we can see, there is a strong Pareto-suboptimal Nash equilibrium[4] formed for cell P,P – an outcome for both players choosing the strategy of defection. In terms of a contractual law, it is a situation in which both agents choose not to fulfil their contractual duties. This is because, by definition, the Nash equilibrium is a situation in which neither party is tempted to unilaterally deviate from their initial choice. Additionally, it states that a player's choice consistent with this notion is immune to the unilateral deviations of the opponent. Again, such a strategy is the one immunising player against the possibility of opponent's defection. Using the Maximin Theorem, we can notice that for the set of the following outcomes: 5 or 0 for following the contractual obligations, and 10 or 1 for defecting, the strategy of defection yields the highest minimal utility for both players[5]. According to the aforementioned theorem, *homo oeconomicus* is a player who maximises minimum payoffs and yet at the same time minimises the opponent's maximum payoffs. This is even more apparent in the situation of a non-iterated asynchronous prisoner's dilemma:

Figure 1. Extensive form of asynchronous prisoner's dilemma



It is visible that by choosing defection in a first move, Player 1 forces Player 2 to choose defection in return. On the contrary, when Player 1 chooses to cooperate he/she is acting at odds with the notion of instrumental rationality. If we assume that for both players it is true that they have common knowledge, then both of them act in compliance with

4 Pareto optimal equilibrium is a Nash equilibrium when the payoff of any of the players cannot be improved without worsening the payoff of the opponent. A Pareto sub-optimal equilibrium is a Nash equilibrium where it is possible to improve players' payoffs without worsening opponents' payoffs.

5 W. Załuski, *Game Theory in Jurisprudence*, Kraków 2013, p. 52–56. For the Maximin Theorem, also referred to as 'Minimax Theorem' or MM, see J. von Neumann, O. Morgenstern, *Theory of games and economic behavior*, Princeton 1947.

the notion of instrumental rationality, or at least one thinks that the other one acts instrumentally rationally. Therefore, Player 1 will never choose to cooperate since in the asynchronous game of prisoner's dilemma this choice will always lead to the worst outcome, that is the loser's payoff.

As we can see, in an asynchronous version of a prisoner's dilemma in non-iterated games it is not the question of actual complying with the contractual terms and fulfilling parties' duty towards a contractual partner but rather a question of lacking any rational incentive to sign a contract without any guarantees stemming from the principle of *pacta sunt servanda*. This principle serves a role of refining the Pareto-suboptimal equilibrium, thereby forcing players to choose the Pareto-optimal strategy of cooperation and fulfilment of their contractual duty. However, in a non-iterated prisoner's dilemma game with both players acting as *homines oeconomici*, it is visible that such a principle does not emerge spontaneously between two parties.

III. Iterated Prisoner's Dilemma

An iterated variant of the prisoner's dilemma is a game in which players play either the simultaneous or non-simultaneous variant of the game and repeat their interactions more than once. Due to this alteration, players must also include in their calculations the potential consequences of their present moves for the future interactions. In this analysis a game with perfect and complete information will be characterised, assuming that for both players it is common knowledge that agents are acting in accordance with the notion of instrumental rationality. In the situation of repetitive interactions between two players, it is visible that the best possible outcome from n number of games is when a universal defector meets a universal co-operator, *ergo* when one of the parties cooperates irrespective of what the other party does, and the opponent uses this strategy to maximise the payoffs by defecting every single time. By using the values from the table no. 1, Player 1 will score a value of $6n$ in an n number of prisoner's dilemma games, while the opponent will score $0n$ (nothing). This is the limit of payoffs in this particular prisoner's dilemma. The Pareto optimal solution is when both players play a strategy of universal cooperation, thus their payoffs will be $5n$. This is the outcome which results from the *pacta sunt servanda* principle and it is Pareto-optimal because it maximises total expected utility for both players. It should be noted that this Pareto-optimal refinement of Nash equilibrium is profitable from the perspective of the society, and it is also a solution to the Nash bargaining problem. In this particular game, we know that the relation between payoffs is as follows: $T > R > P > S$. Since it is a prisoner's dilemma game and additionally $S=0$ for a contractual situation, this is the loser's payoff and $R+S=P$ because a maximised defection strategy will result in a player having both the money and the goods. Therefore, if we try to define an optimal strategy for Player 1 playing against Player 2, who can be either a Universal Defector (UD) or a Universal Co-operator (UC), we need to introduce the concept of a third player, the Nature. It chooses from the spectrum of Universal Defection (UD) and Universal Co-operation (UC) the opponent to the Player 1. The Nature is neutral towards the game itself as it does not yield any payoff no matter what action it pursues. Moreover, it chooses the characteristic of the opponent with probability p. Player 2 is, therefore, a UD with probability p, or a UC with probability $1-p$. Hence, as the best strategy against a UD is UD, Player 1 should play UD with probability $q=1$ against such a player, since P > S. Furthermore, the best strategy used against a UC is also to defect universally; Player 1 should also play UD with probability $z=1$, since T > R. To conclude, no matter what type of opponent is faced by Player 1, he/she should always play UD as it is the best response to both the UD and UC strategies.

Table 2. Optimal strategy for Player 1 playing against a Universal Defector

	Universal Defection
Universal Cooperation	T,S
Universal Defection	P,P

It is clearly visible that the optimal strategy against both types of players is for Player 1 to always choose the strategy of Universal Defection. However, because we are considering an iterated version of the prisoner's dilemma, neither does the UD nor the UC strategy finish the universe of possible strategies for Player 1. Robert Axelrod asked mathematicians to submit strategies encoded in a form of an algorithm of a computer program, which were later put to play against one another[6]. As a result, it was established that the best strategy, while playing against whatever moves the opponent makes, is the one of Tit-For-Tat (TFT)[7]. The concept of TFT is surprisingly simple: in the first move a TFT player cooperates, and in the second and every other move it repeats what the opponent has done. Therefore, after a TFT strategy is put against a Universal Defector, a TFT acts as if he/she was playing a strategy of Universal Defection. TFT played against a UC becomes itself also a Universal Co-operation. TFT played against TFT becomes a strategy of Uni-

6 D. Hofstadter, *Metamagical Themas: Computer Tournaments of the Prisoner's Dilemma Suggest How Cooperation Evolves*, Scientific American 248/1983, p. 10.

7 See R. Axelrod, W. D. Hamilton, *The Evolution of Cooperation*, Science 4489/1981, p. 1390-1396; R. Axelrod, *The Evolution of Cooperation*, New York 1984.

versal Cooperation as well. The TFT is, therefore, a strategy that works well in various environments, as it is an effective response to the UC, the UD and itself. Axelrod called such strategies *robust*[8].

Moreover, after the first tournament held by Axelrod, it was established that it is important to have "a policy of cooperation as often as possible, together with a willingness to retaliate swiftly against any attempted undercutting"[9]. TFT is also resistant to any strategy employing probing of the opponent with occasional defection as means of either boosting the total payoff of the opponent or probing the player using TFT. Let us assume that Player 1 uses the TFT strategy and Player 2 uses a TFT strategy with a small alteration, as he/she defects in every round with probability p equal to 10%. This strategy is called JOSS[10].

Table 3. A TFT player playing against a JOSS player

	I	II	III	IV	V	VI
Player 1 (standard TFT)	C (5)	C (0)	D (6)	C (0)	D (1)	D (1)
Player 2 (JOSS)	C (5)	D (6)	C (0)	D (6)	D (1)	D (1)

It is visible that in such a situation, after the first defection of Player 2, both players started to retaliate mutually, which significantly reduced both players' payoffs from an average of 5 per turn before the defection to (6+0)/2=3. Furthermore, the second defection in round V eventually leads to both players playing a Universal Defection strategy and decreasing their average payoffs per turn to 1. This resistance to opponents' attempts to probe a TFT player, or to take advantage of TFT's inclination to cooperate, can also be interpreted as vulnerability of JOSS strategy to the possibility that the opponent has made a mistake.

There are two alternative versions to the Tit-For-Tat strategy: the Tit-For-Two-Tats, when a retaliation of Player 1 happens only after the Player 2 has defected twice in a row; and Two-Tits-For-Tat, when the retaliation of Player 1, after the defection of Player 2, lasts for two turns instead of one[11]. The first strategy appears to be a better response to Player 2

8 D. Hofstadter, *Metamagical Themas: Computer Tournaments of the Prisoner's Dilemma Suggest How Cooperation Evolves*, Scientific American 248/1983, p. 10.

9 *Ibidem*, p. 9.

10 JOSS's strategy is very similar to TIT FOR TAT strategy in that it begins by cooperating, always responds to defection by defecting and nearly always responds to cooperation by cooperating. The hitch is that JOSS uses a random number generator to help it decide when to pull a "surprise defection" on the other player. JOSS is set up so that it has a 10 percent probability of defecting right after the other player has cooperated (*Ibidem*, p. 9).

11 *Ibidem*, p. 8.

who, using a basic TFT strategy, makes a mistake and defects instead of cooperating, since it eliminates random mistakes from the otherwise effective cooperation. However, the Tit-For-Two-Tats can be exploited by a player who uses defection as a means of probing Player 1 or a way to boost his/her payoff by scoring a T instead of an R once in a while. The Two-Tits-For-Tat is better in disciplining the opponent and deterring the opponent from defection, but it can result in largely lowering both players' payoffs. In the second Axelrod tournament, a submitted Tit-For-Two-Tats strategy came in twenty-fourth and the submitted standard Tit-For-Tat strategy came first[12]. Two Axelrod tournaments have proven that the Tit-For-Tat strategy is evolutionary stable. A population of species applying the rules of this strategy achieves an overall score higher than the one applying the others. It does not mean that TFT is always better than other approaches, but when we combine the results of many iterations of the same prisoner's dilemma played among different agents and employing different strategies, it is Tit-For-Tat that turns out to be the simplest solution presented and which yields the best overall result. If we consider the TFT and UD as separate strategies that are applied before the start of the game and unalterable during the tournament, and if we treat the total payoffs as a singular payoff from a single application of a given strategy, we can then transform the iterated prisoner's dilemma into a singular game with the following characteristics:

Table 4. An iterated prisoner's dilemma played between a TFT player and an UD player, presented as a *Stag hunt* game

P1/P2	TFT	UD
TFT	500,500	99,106
UD	106,99	100,100

P1/P2	TFT	UD
TFT	nR, nR	(n-1) P+S, (*n*-1) P+T
UD	(n-1) P+T, (n-1) P+S	nP, nP

The number of iterations (n) is equal to 100. As we can see, in this situation there is a strong Pareto optimal Nash equilibrium formed for TFT, TFT and a strong Pareto sub-optimal Nash equilibrium formed for UD, UD. This result is consistent with the Axelrod's notion of superrationality[13].

[12] *Ibidem*.
[13] Superrationality is a concept of rationality developed by Douglas Hofstadter as a solution to the non-

IV. The swift and imminent retaliation in Tit-For-Tat strategy

The biggest advantage of the TFT strategy is the fact that it promotes cooperation between players. As we have previously shown, a TFT player always cooperates with players willing to cooperate, but, at the same time, he/she is resistant to any attempt to exploit this inclination by defecting opponents. Therefore, this strategy is consistent and very flexible at the same time. However, is it possible that, because this strategy is evolutionary stable and in the long run players applying its rules are better off than others in interactions, it can induce a sort of rudimentary rule among players? Since TFT is applicable only in games with perfect information[14], it is possible for rational players to either foresee the opponents' moves, using the notion of superrationality[15], or, at a certain stage of the iterated game of prisoner's dilemma, to internalise the principles according to which Player 1 is playing. The Axelrod's tournaments have proven that the best strategies are those that are flexible, forcing swift retaliation, and forgiving[16]. For every defection of Player 2, Player 1 defects once. The actions of Player 1 as a response to the defection of Player 2 are punitive. Assume that the optimal situation is when both players cooperate. For such a situation the payoffs are an R for each player. Player 2's action results in a deviation of payoffs from this optimal situation. Therefore, the standard yield from two turns for each player is 2R. When Player 2 defects instead of cooperating, he/she then scores a T instead of an R (T>R). In the next round Player 1 will for sure play a strategy of defection as it is a normal response to the opponent's defection. If Player 2 chooses to cooperate, he/she will receive the loser's payoff (S=0) in the next round, but if he/she chooses to continue defection, the score will be a P (R>P>S and P≠0). Therefore, for one defection the loss of expected marginal utility can be expressed in the following way: (R-P)+(R-T)). After we include

-iterated prisoners dilemma. In his article, Hofstadter argued that a spontaneous cooperation may emerge even without repetitive interactions among total strangers. When a superrational player is choosing a strategy and is put against another superrational player, he/she bares in mind that in such case they both will come up with a correct solution to a symmetric problem. Therefore, to a symmetric problem stated in the prisoners dilemma, there are only two symmetric solutions: both agents either defect or cooperate. Superrational players will choose to co-operate as only this choice will maximise their payoffs. This notion of rationality is, however, not widely accepted, see: D. Hofstadter, Dilemmas for Superrational Thinkers, Leading up to a Luring Lottery and Irrationality Is the Square Root of All Evil [in:] D. Hofstadter, Metamagical Themas: Questing for the Essence of Mind and Pattern, Scientific American 1985, p. 739–780.

14 Or at least in games with perfect information about the preceding moves, since TFT always repeats the opponent's move. The other information about what were the actions of players at earlier stages of the game is irrelevant.

15 See *supra* note 17.

16 R. Axelrod, *supra* note 11.

the possibility that Player 2 uses the strategy of cooperation instead of defection in the second move, the loss in the expected marginal utility for the iterated prisoner's dilemma, using the matrix of payoffs presented above, is greater than or equal to 4. Hence, we can estimate a specific, stable quantum of severity in Player 1's retaliation against Player 2. Additionally, the loss in the expected marginal utility is not a direct logical consequence of Player 2's action at the ontological level[17]. In legal theory, the *conditiones sine quibus non* for regarding the actions taken against another actor as a punishment are as follows. Firstly, it is only a quantum of severity dealt against an acting agent that can be regarded as a punishment[18]. Secondly, it can be considered as a punishment if and only if it is not a direct result of actions at the ontological level[19]. On the basis of this analysis, in our opinion, it is possible to treat Player 1's action in turn no. 2 as a sort of a sanction. From what was stated above, it is possible to reconstruct a rudimentary disposition of a norm governing the relation between two agents in a contractual situation depicted in the presented prisoner's dilemma. At the level of the sanctioned norm, it is stated that the players should cooperate, *ergo* fulfil their contractual obligations[20]. The sanctioning norm's disposition is as follows: if Player 2 defects, Player 1 should defect in the second turn (sanction), and thus inhibit the yield of expected marginal utility of the opponent[21]. The characteristic and genesis of this norm of social behaviour are expressed best by the notion of convention which also explain relationships of actions. Convention can be defined as a regularity in behaviour of members of a given population in a recurring situation. This phenomenon is triggered by the sense of common interest felt by the players and, therefore, contributes to the public utility. What is more, players expect such behaviour from their opponents[22]. This Humean notion of convention describes accurately the emergence of a certain rule of behaviour between two TFT players. They choose to cooperate because they expect the same from their opponents. It is in their common interest to behave in such a way and a rule of behaviour stems from the regularity in their behavioural actions in the consequent turns of the iterated prisoner's dilemma. Therefore, on the one hand players cooperate due to a convention that spontaneously establishes itself between them, and, on the other hand, they are protected from any exploitation caused by deviation from this rule thanks to a form of a sanction embedded in the TFT strategy and transferred into this convention.

17 See: W. Wróbel, A. Zoll, *Polskie Prawo Karne, Część Ogólna*, Kraków, 2010, p. 411–412.
18 *Ibidem.*
19 *Ibidem.*
20 *Ibidem*, p. 110–113.
21 *Ibidem.*
22 D. Hume, *An Enquiry Concerning the Principles of Morals*, London 1751, reprint.

As it has been shown above, an iterated version of a prisoner's dilemma can be viewed as a coordination game characterised by: a strong Pareto sub-optimal Nash equilibrium for UD, UD strategies and a strong Pareto optimal equilibrium for TFT, TFT strategies. This is consistent with the characteristics of *the Stag Hunt* game, as neither of the chosen states is more advantageous only to one player, but for both players to play the same strategies. A social norm diverting players from choosing tactics that lead to a Pareto sub-optimal equilibrium can be considered as a form of Nash equilibrium refinement[23]. Therefore, in order to obtain a Pareto optimal choice it is necessary to apply certain rules of behaviour to the population lack of consideration. Number n of members of the population following the rules of TFT is immune to external interference. This means that in spite of the fact that the equilibrium for strategies TFT is dominant, this strategy is evolutionary stable[24]. Additionally, by applying the notion of mixed strategy equilibrium with the following data given:

Table 5. A mixed strategy Nash equilibrium for a TFT and UD strategies in an iterated prisoner's dilemma game

P1/P2	TFT p (1/395)	UD 1-p (394/395)
TFT q (1/395)	500,500	99,106
UD 1-q (394/395)	106,99	100,100

We receive the following equation: $500p + 99(1\text{-}p) = 106p + 100(1\text{-}p)$, p=1/395. Therefore, in an iterated prisoner's dilemma, a game theoretically rational player will play the mixed strategy of TFT with probability p equal to 1/395 (and UD with probability equal to 394/395). On the one hand, this means that cooperation among players of an iterated prisoner's dilemma can emerge spontaneously without any prior existence of social norms, let alone legal norms defining contractual obligations. Because in any case it is irrational to defect playing against player choosing the Tit-For-Tat strategy, the interests of cooperating parties is well-protected by the chosen strategy itself, remaining indifferent to the

[23] Every refinement in the strict sense must *imply* Nash equilibrium, while the concept of Pareto-optimality does not meet this requirement Pareto optimal outcomes need not be Nash equilibrium (W. Załuski, *op.cit.*, p. 42). However, a Pareto-optimal Nash equilibrium implies a Nash equilibrium, so it has been suggested that a conjunction of the Nash equilibrium concept with that of Pareto-optimality could be regarded as a refinement in the strict sense of the concept of Nash equilibrium, see W. Załuski, *op.cit.*, p. 42–43.

[24] *Ibidem*, p. 128–133.

moves of the other player. On the other hand, the rules governing the TFT strategy and the reasons why the UD strategy remains evolutionary stable, indicate the importance of trust in contractual situations.

V. Trust as a pre-requirement of cooperation

Hugo Grotius has formulated *pacta sunt servanda* as a law of nature stemming from the nature of human being[25]. This principle must be considered as a right second-order principle of justice that simultaneously guarantees the fulfilment of a contractual obligation, by enabling a negative obligation to happen, and by making a positive obligation act in an way expected by the contractual obligation[26]. Therefore, in order to accomplish the aim of *pacta sunt sunt servanda*, which is to induce cooperation of players who fulfil their obligations, it is necessary to establish trust between them. Thus, for a member of society following the TFT strategy, it is necessary to establish whether he/she deals with another TFT or a UD. If the person deals with a TFT, then he/she acts as if he/she was a Universal Co-operator; and if Universal Defector is encountered, starting from the second turn, then he/she plays as if he/she was a Universal Defector. For a sufficient amount of time and iterations, there appears an obvious advantage in the accumulated marginal utility for TFTs over the UDs. Therefore, the TFTs population in a group may expand. The cooperation among the TFTs is conditioned only by trust, and is vulnerable to intentional or unintentional deviations from cooperation to defection[27]. In order to establish cooperation among the members of a group, the following requirements must be met: 1) a group of players, 2) for whom it is a common knowledge that every member of this group acts in accordance with the notion of instrumental rationality, 3) perfect information about previous stages of the game, and 4) continuous, iterated interactions among these members. In such conditions a spontaneous cooperation in the game of the prisoner's dilemma is possible. However, it will only last until both players trust each other. This trust is

25 Grotius asserted that: "(F)or those who had associated themselves with some group, or had subjected themselves to a man or to men, had either expressly promised, or from the nature of the transaction must be understood impliedly to have promised, that they would conform to that which should have been determined, in the one case by the majority, in the other by those upon whom authority had been conferred" (H. Grotius, *On the Law of War and Peace*, S.C. Neff (ed.), Cambridge 2012, p. 5).

26 G. Sartor, *Doing Justice to Rights and Values: Teological Reasoning and Proportionality* [in:] *Studies in the Philosophy of Law VII*, Kraków 2011, p. 18–24.

27 For the analysis of another variant of the Tit-For-Tat strategy, namely, the Tit-For-Two-Tats strategy see also text accompanying *supra* notes 15–16. A player acting Tit-For-Two-Tats is immunised to singular errors of the otherwise cooperating opponent.

based on the continuous repetition of the strategy of cooperation and the belief inside both players that the cooperation will not terminate in the next move. If it is known to either of the players that the iterated prisoner's dilemma will terminate in the next move, than one is tempted to choose a strategy of cooperation on the basis of the TFT strategy than to defect, and thus increase a payoff, without the possibility of losing an expected marginal utility of total payoffs from future iterations (as there will be none). In such a situation the game between a TFT and a UD switches back from *the Stag Hunt* game to the classic prisoner's dilemma. This can also be explained by the notion of a discount rate. In the second Axelrod tournament, the number of iterations of the prisoner's dilemma between players was determined by the δ factor[28]. This value varies from 0 to 1 ($0< \delta<1$). δ factor represents both a perceived probability that the game continues for yet another turn, and also the value of future payoffs versus present ones[29]. The higher the value of δ is, the longer the game will last; and the higher the total value of payoffs will be. This is expressed by the following formula for the yields for a particular strategy for TFT vs. TFT:

$$R+ \delta R+ {}^2R+ \delta^3R+\ldots = R(\delta+ \delta^2+ \delta^3+\ldots) = R/(1- \delta).$$

The value of δ is influenced by such factors as the cementation of the group, the number of its members or the interest rate and inflation. The stronger the interdependency of the members of the group and the group's cohesion is, the higher the perceived number of future itineration of interactions for each member will be. The iterated prisoner's dilemma will only occur in smaller groups with stable memberships, where each of the players is forced to interact with others. Therefore, trust may only emerge in such communities where the number of iterations is high. This is because it is necessary to sustain the mutual interactions for a period of time long enough that in case of an eventual opponent's switching to defection, TFT retaliation (or, for example, the *Grimm Trigger*[30] retaliation) causes serious inhibition in opponent's payoffs. This would not happen if the interactions were singular or brief, so that the chance of actual inhibiting the score was very low.

VI. Conclusion

The *pacta sunt servanda* rule can emerge spontaneously between members of a certain group. However, there are certain requirements and limitations to this phenomenon.

28 W. Załuski, *op.cit.*, p. 121.

29 It is based on an assumption that the money today is more valuable than the money tomorrow.

30 When after a singular defection of the opponent Player 1 switches her strategy straight to defection until the game ends.

Firstly, it is necessary that the interactions between members of the group are repetitive rather than occasional. In both the synchronous and asynchronous versions of the non--iterated prisoner's dilemma, the fulfilment of contractual obligations is irrational according to a game theory. Additionally, bearing in mind the assumption that all the players know that their opponents act in accordance with the notion of instrumental rationality, players have no incentive to sign a contract without any prior guarantees external to the contract ensuring its fulfilment. In non-iterated games of prisoner's dilemma, players will always stick to their Maximin strategies if there are no institutionalised rules enforcing the fulfilment of contractual duties.

Secondly, the spontaneous cooperation will occur only between players playing an iterated version of the prisoner's dilemma, choosing a Tit-For-Tat strategy or any of its variants. The introduction of the TFT in the Axelrod tournaments made it possible to transform the prisoner's dilemma to *the stag hunt* game between players who choose from either the Universal Defection or the TFT strategy. In the iterated version of the prisoner's dilemma, there is an additional strong Pareto-optimal equilibrium for TFT. When a TFT player plays against a TFT opponent, they both cooperate as if they were both playing a Universal Cooperation strategy. Furthermore, since the TFT strategy is evolutionary stable, it is immune to any invasions of actors applying Universal Defection strategy, or any other.

Thirdly, a retaliation of Player 1 against a defecting Player 2, who deviates from the previously established cooperation, can be viewed as a sanction under the *pacta sunt servanda* norm. After a sufficient number of iterations, such a norm of behaviour may spontaneously emerge between two players as they both internalise each other's strategies. Therefore, they become able to anticipate the moves of the opponents. In the TFT strategy, the retaliation occurs as a result of the opponent's defection. This can be described using the concept of a norm that defection is forbidden. If somebody defects, the other party will defect as well. This is a norm of social behaviour which is accepted by players as a convention, and serves as a refinement to the Nash Equilibrium. It diverts the stable state of the game from the Pareto sub-optimal outcome to an optimal one.

Finally, the necessity of repetition of the prisoner's dilemma emphasises the requirement of trust between players. Trust is an attitude of a player who continues cooperation with the opponent for yet another round. The previously explained norm of social behaviour discourages players from defecting, while trust encourages them to continue cooperation. Cooperation will be continuous and long-lasting when the discount rate is high enough. This would happen in a small, interdependent and coherent group, with a stable membership and in conditions of low interest rates and inflation. In these cases it is of a paramount importance to sustain long relationships.