Yugoslav Journal of Operations Research
(20##), Number #, #-#
DOI: https://doi.org/10.2298/YJOR250425034M

Research article

EXPLANATORY POWER OF THE TULLOCK CONTEST AS AN INTEGRAL PART OF GAME THEORY IN POLITICAL ADVERTISING SPENDINGS

Petr MACH

University of Finance and Administration, Czech Republic,
petr.mach@vsfs.cz, ORCID: 0000-0002-1379-3703

Klara CERMAKOVA*

University of Finance and Administration, Czech Republic,
klara.cermakova@vsfs.cz, ORCID: 0000-0003-4392-1611

Received: April 2025 / Accepted: August 2025

Abstract: This article deals with a concept known as the Tullock contest, frequently applied to game theory decision-making in lotteries, lobbying, advertising, the military, politics, biology and other areas. While the theory of the prisoner's dilemma explains that the rational choice of players is to defect with a resulting payoff that is lower than what would flow from cooperation, the Tullock contest is a model that explains what the value of the chosen strategy will be and what the resulting payoff will be. The Tullock contest is developed here in the context of the prisoner's dilemma and game theory. Best response functions of the Tullock contest are derived both algebraically and graphically, and the Nash equilibrium is shown. This paper confirms that some of prisoner's dilemma games may be characterized as Tullock contests. We propose an explanation for high advertising expenditure in political campaigning games and we offer a numerical example of the equilibrium expenditure resulting in some positive payoff for each player. We prove that, on the other hand, international environmental agreements cannot be characterized as Tullock contests, thus prisonner's dilemma game in these cases end up in a defect-defect Nash equilibrium with a payoff of zero for each player.

Keywords: Tullock contest, Prisoner's dilemma, best response functions, Nash equilibrium, political advertising.

MSC: 62C91-08

*Corresponding author

1. INTRODUCTION

Game theory established itself as a separate discipline with its own methodology and its own key concepts with the publishing of the book *The Theory of Games and Economic Behavior* by John von Neumann and Oskar Morgenstern in 1947 [1]. Many authors then have contributed significantly, with John Nash [2] being the most prominent contributor. Nash equilibrium (NE) and best response functions (BRFs) belong among the most important concepts of the theory.

However, long before the establishment of game theory, several groundbreaking ideas emerged that we now know to clearly belong to game theory. Antoine Augustin Cournot [3] published a model of oligopolistic competition, which is now called Cournot Competition. Although Cournot did not use the now established terms NE and BRF, his model uses them under other names and fully applies the methodology of modern game theory. Therefore, today, the Cournot model is included in most game-theory textbooks [4] [5]. The same can be said, for example, of the Stackelberg model or the Bertrand model of oligopolistic competition.

In this article we argue that the model outlined in the article *Efficient Rent-seeking* by Gordon Tullock, often referred to as the "Tullock Contest" [6] (in the same way as Cournot's model is usually labeled as "Cournot competition"), can be used for some prisoners dilemma games. We seek for application of this policy in environmental policymaking.

Like Cournot's model, Tullock's model was written independently of game theory and did not use its current terms, and as Cournot competition, the Tullock contest deserves to be a recognized part of Game theory. Tullock wrote his model to explain equilibrium in rent-seeking and he compared it to investing in lottery tickets. The model is applicable in many other areas such as advertising, oligopolistic pricing, military science, biology, social sciences. In this article we argue that the Tullock Contest is a rigorous approach in many areas of policymaking where the prisoner's dilemma (PD) is applicable.

The Tullock contest, a concept rooted in game theory, provides a framework for understanding competitive behaviours in various contexts, including environmental economics and pollution regulation. This literature review synthesizes recent contributions to the understanding of Tullock contests within the realms of game theory, environmental policy, and regulation, emphasizing their implications for pollution control and sustainable practices.

Game theory serves as a critical analytical tool in environmental economics, particularly in modeling interactions among stakeholders involved in pollution control. For instance, Sadik-Zada [7] highlights the utility of game theory in addressing socio-environmental challenges, proposing resilience policies that can mitigate anthropogenic impacts on environmental quality. Similarly, Sumaila et al. [8] discuss how game theoretic frameworks can be applied to assess environmental regulations and policies, providing insights into natural resource management issues such as pollution and climate change. These frameworks allow for the exploration of strategic interactions among various players, including governments, firms, and the public, thereby facilitating a deeper understanding of collective action problems inherent in environmental governance.

The dynamics of regional cooperation and non-cooperation in pollution mitigation can be effectively modeled using game theory. Yang et al. [9] present a dynamic game model that considers the spatial spillover effects of air pollution, illustrating how regional economic disparities influence cooperative strategies in pollution control [9]. This

approach aligns with the Tullock contest framework, where the competition for environmental quality can be viewed as a contest among regions or firms, each attempting to maximize their utility while minimizing pollution. The findings underscore the importance of cooperative strategies in achieving effective pollution mitigation, particularly in contexts where pollution transcends regional boundaries.

Moreover, the application of evolutionary game theory further enriches the analysis of environmental policies. For instance, Zhou et al. [10] explore the impact of heterogeneous environmental regulation policies on corporate pollutant discharge strategies, revealing how evolutionary dynamics can influence firms' compliance behaviors. This perspective is crucial for understanding how firms adapt their strategies in response to regulatory pressures, which is a central concern in the Tullock contest framework where players adjust their efforts based on the actions of their competitors.

The interplay between government regulation and corporate behavior is also a focal point in the literature. Tapiero [11] discusses how game theory can elucidate the challenges faced by regulators and polluting firms in establishing effective environmental control policies. By framing these interactions as a game, policymakers can better understand the incentives and disincentives that shape corporate environmental responsiveness. This understanding is vital for designing regulations that not only compel compliance but also encourage proactive environmental stewardship among firms.

In addition to regulatory frameworks, the role of social norms and identities in influencing pro-environmental decision-making is highlighted by Chen [12], who examines how environmental serious games can promote sustainable behavior. This aspect is particularly relevant to the Tullock contest, as the competition for environmental quality is not solely driven by economic incentives but also by social dynamics that can either reinforce or undermine collective action efforts.

In conclusion, the Tullock contest framework, when integrated with game theory and environmental economics, provides a robust lens through which to analyze the complexities of pollution control and environmental policy. The literature reveals that strategic interactions among stakeholders, influenced by regulatory frameworks and social norms, play a pivotal role in shaping environmental outcomes. Future research should continue to explore these dynamics, particularly in the context of evolving environmental challenges and the need for innovative policy solutions.

Political advertising spending has expanded significantly in recent years, with campaigns increasingly employing advanced marketing techniques to engage with voters [13]. Research into the effects of campaign advertising reveals a substantial body of theoretical and empirical studies. The analysis of campaign spending on electoral outcomes has yielded mixed results. Some findings suggest advertising influences voter learning, attitudes, and turnout [14,15,16], whereas others highlight more limited impacts [17,18] [19]. These multifaceted outcomes reflect the complexity of political advertising's role in shaping voter behavior.

The theoretical underpinnings of political advertising frequently rely on models such as the Tullock contest framework, which conceptualizes advertising as rent-seeking competition, where spending escalates until marginal benefits equal marginal costs [20,21,22,23]. Game-theoretic studies enrich this perspective by analyzing variables like asymmetric information, strategic interaction, and deception in decision-making processes [24,25,26]. These theoretical approaches emphasize the strategic dimension of advertising and its influence on shaping campaign dynamics.

Empirically, diverse methodologies such as field experiments, difference-in-differences, and border discontinuity designs have been employed to evaluate the causal effects of political advertising on elections [27,28,29]. These studies generally indicate that advertising has modest but measurable impacts on vote shares, influenced by tonal and content aspects of advertisements as well as targeting strategies [30,31,32]. However, questions regarding the geographic and long-term effects of advertising remain unresolved, underscoring the need for further investigation [33,34].

Political advertising also intersects with various campaign activities and media coverage [35,36,37]. Notably, the tone and content of ads have been linked to perceptions of campaign negativity and polarization [38]. The advent of digital platforms has introduced new challenges and opportunities, reshaping the landscape of political communication and advertising strategies [39,40,41]. This evolution highlights the dynamic nature of the media environment and its potential implications for voter engagement.

The discussion extends further when examining the financial practices linked to political operations. The literature identifies significant relationships between political, institutional, and cultural factors and their influence on financial assessment and disclosure practices [42,43,44,45,46]. Specifically, political factors such as competition, fragmentation, and government ideology play a role in shaping financial sustainability practices within local governments, while the extent of political connections and cronyism can impact financial reporting and resource accessibility [46,47,48,49].

Institutional factors, such as the regulatory environment, governance mechanisms, and legal traditions, also affect transparency and financial outcomes [44,50]. These influences can lead to varying degrees of institutional development and financial system integration, underscoring the interplay between political intervention, institutional quality, and financial system performance [42,45]. Similarly, cultural norms and religious factors may influence financial irregularities, earnings management, and systemic developments, further demonstrating the interconnectedness of these dimensions [52,53].

From a practical standpoint, the financial performance and accountability of political parties remain underscored as key concerns. Issues related to party funding regulations highlight challenges in ensuring transparency and accountability. For example, findings from South Africa emphasize good records management as essential for improved accountability [54], while studies from Indonesia and Romania point to insufficient enforcement mechanisms and regulatory loopholes affecting financial accountability and access to state resources [55,56]. Such deficiencies can erode public trust in political systems and expose party structures to systemic risks of cronyism and instability.

Furthermore, connections between political funding and electoral performance reveal how weak financial regulations hinder meaningful democratic engagement and party development [57,58]. Effective governance frameworks are needed not only for fiscal discipline and resource negotiation but also for the institutionalization of political organizations. Studies emphasize the democratizing role of party institutionalization, pointing to its significance in deepening voter-party relationships and facilitating reliable governance structures [59,60].

In conclusion, the intertwined themes across these areas underscore the multifaceted impact of advertising spending, financial accountability, institutional influence, and cultural context on political processes. While notable progress has enriched our understanding of these dynamics, further research is imperative to bridge gaps in

knowledge and to refine policies that enhance transparency, accountability, and democratic engagement within the evolving landscape of political competition and financial governance. Our aim is to identify characteristics of prisoner's dilemma games where the Tullock contest is applicable with reflection for environmental policy decision-making.

We believe that integrating the Tullock Contest into the standard Game Theory creates a useful framework for analyzing various interactions (among individuals, firms or countries) that constitute prisoners' dilemmas. The existing literature does not integrate fully the Tullock contest into Game theory. Our approach will enable to distinguish two types of Prisoner's dilemma, one which constitutes a Tullock contest and one which does not, depending on the characteristics of the payoff (profit) functions.

The article will proceed as follows. First, we will explain the basics of Tullock's model, as presented by Tullock himself. Then, we will derive the model algebraically and provide the necessary calculations that Tullock skipped or omitted in his article. Then, we will place Tullock's model in the context of Game theory and show the best response functions and Nash equilibrium in the Tullock contest. Finally, we will present possible applications of Tullock's model in connection with the Prisoner's Dilemma.

2. TULLOCK CONTEST – THEORETICA BACKGROUND

Tullock [61] formulated a game describing the contest between two persons trying to win a trial. Who wins depends on the amount spent on lawyers in the same ways as the success in a lottery depends on how many tickets one buys: "*Suppose that a sum of money is put up for a prize for a particular form of lottery. The lottery has only two contestants and each of them may buy as many tickets for the lottery as he wishes for $1 each. One ticket is drawn at random, and the owner of that ticket receives the prize. Note that the payments for this tickets are not added on the prize.*" (p. 752)

Later Tullock [62] further developed the idea that appeared in the above-mentioned article and provided basic mathematical formalisation of the model.

"*Let us assume, then, that a wealthy eccentric has put up $100 as a prize for the special lottery between A and B. Note that the amount spent on lottery tickets is retained by the lottery, not added onto the prize.*"…"*How much should each invest? It is obvious that the answer to this question, from the standpoint of each party, depends on what he thinks the other will do.*"… "*As a matter of fact, the optimal strategy in this game is not to buy $50.00 worth of tickets but to buy $25.00.*" (p. 5)

Tullock noted that this lottery game is equivalent to a rent-seeking contest between two lobby groups seeking for some change in legislation. We can argue that it is also equivalent to a contest between two advertising firms seeking to gain a bigger market share. It is also equivalent to a fight between two countries over a territory and to many other situations in which contestants try to gain part of a "pie" at the expense of the other party whereas the share or the probability of success of one party depends not only on the investment of this party but also on the investment of the other party.

Although Tullock was not explicit in providing the profit function, he concluded that optimal investment (in case of two contestants) is

$$A = \frac{1}{4}R. \tag{1}$$

where R is the prize that can be won in the lottery or the rent that can be gained through rent-seeking, or, as could be argued, additional profit that could be gained through advertising, or the value of a territory that can be conquered or kept through a war effort

in terms of soldiers and weapons invested, or the value of any other thing that is the subject of this sort of a contest.

Tullock did not provide the calculation that led to equation (1). He just noted that a mathematician at the university told him about the resulting formula during a lunch. [62] (p. 16)

Tullock was neither only one nor the first one to present a model that includes strategic behaviour and the expected profit that depends on the proportion of the exerted efforts of contestants. As John D. D. Little noted before Tullock's *Efficient rent-seeking* was published, "*Response models of the general type us/(us + them) are well known.*" [63] (p. 20) However, the Tullock article had the biggest impact, and now this sort of models is usually labelled as the "Tullock contest" in the literature on this topic.

3. DERIVATION OF THE MODEL

As noted earlier, Tullock concluded, that, in equilibrium, each of two contestants will invest one fourth of the rent that can be gained, without providing detailed calculations that led to this result. He just said that "*it is a matter of fact*" [62] (p. 5).

In this section, we will present the calculations that are behind Tullock's findings to present the model in a clear way.

In the simplest two-player version of the model, there are two contestants, A and B, investing amounts A and B respectively into a contest over some "pie" (be it a lottery promising a prize, rent-seeking with a possible rent, a military operation with a chance of keeping or gaining territory, advertising effort with a chance to gain a bigger market share, and so on).

The probability of success, or contestant's expected share are given by the ratio of each contestant's effort (investment) to the sum of both efforts. The amount that will be won is denoted with the symbol R (referring to a rent in rent-seeking).

The probability of A's success or A's expected share is

$$p_A = \frac{A}{A+B}. \tag{2}$$

A and B are non-negative numbers (because they represent investments that cannot be negative) and the sum $A + B$ cannot be zero because dividing with zero is not defined.

The expected profit π_A that contestant A is supposed to maximize is therefore the probability-weighted rent minus the investment:

$$\pi_A = p_A \cdot R - A = \frac{R \cdot A}{A+B} - A. \tag{3}$$

This expected payoff function is maximized where its derivative with respect to effort equals zero:

$$\frac{d\pi}{dA} = 0.$$

For calculating the derivative, we will apply the quotient rule of differentiation of functions,

$$f'(x) = \frac{g'h - h'g}{h^2}.$$

So, we get

$$\frac{R \cdot (A+B) - R \cdot A}{(A+B)^2} - 1 = 0 \tag{4}$$

Tullock assumed that if there is an equilibrium amount A for contestant A, contestant B's equilibrium amount must be the same:
$A = B$,
which gives after substituting to equation (4)

$\frac{R \cdot 2A - R \cdot A}{(2A)^2} - 1 = 0$ or $A = \frac{1}{4}R$.

4. BEST RESPONSE FUNCTIONS AND NASH EQUILIBRIUM IN TULLOCK CONTEST

We will show that Tullock's assumption that in equilibrium the two efforts must be identical is equivalent to the concept of Nash equilibrium, a key concept of Game theory. As Game theory claims, NE lies at the intersection of the two best-response functions of both contestants. To put the Tullock contest into the framework of Game theory, we will derive the corresponding best-response functions of the game and the Nash equilibrium. Applying these concepts yields the same results as Tullock's approach. We will provide a graph of the two BRFs and the corresponding NE in a similar way that Game theory standardly provides for other strategical models, such as Cournot competition.
From equation (4) we get

$RA + RB - RA = A^2 + 2AB + B^2$,

which gives a squaring equation in the standard form of

$A^2 + 2BA + (B^2 - RB) = 0$

Which, solved (for non-negative A), gives

$$A = \frac{-2B + \sqrt{4B^2 - 4B^2 + 4RB}}{2} = \sqrt{RB} - B. \quad (5)$$

Equation (5) is contestant A's best response function to effort made by contestant B. The graph of this BRF is a skewed parabola (see Fig. 1).

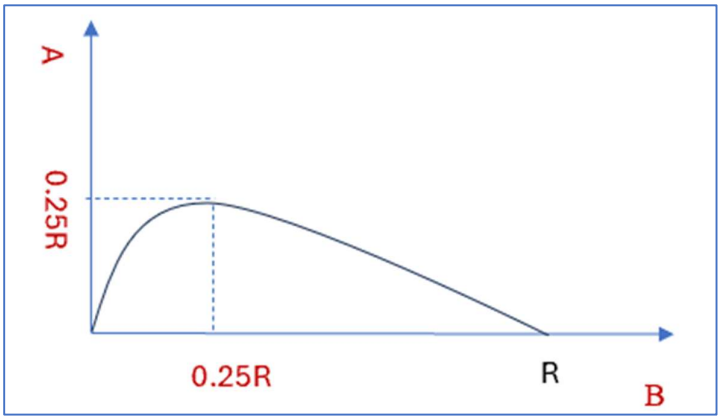

Figure 1: BRF of contestant A in the Tullock contest (R=1)
Source: Authors' own graph based on equation (5)

The model is symmetrical. Therefore, contestant B's probability of success or expected share is

$$p_B = \frac{B}{A + B}$$

and the expected profit π_B that the contestant is supposed to maximize is

$$\pi_B = p_B \cdot R - B = \frac{R \cdot B}{A+B} - B.$$

Therefore, contestant B's BRF is

$$B = \sqrt{RA} - A. \tag{6}$$

Nash equilibrium, the solution of the model, lies at the intersection of the two BRFs, that is where contestant B's BRF is substituted to contestant A's BRF (equation (5)):

$$A = A - \sqrt{RA} + \sqrt{R(\sqrt{RA} - A)}$$

that is

$$A = \frac{1}{4}R = B.$$

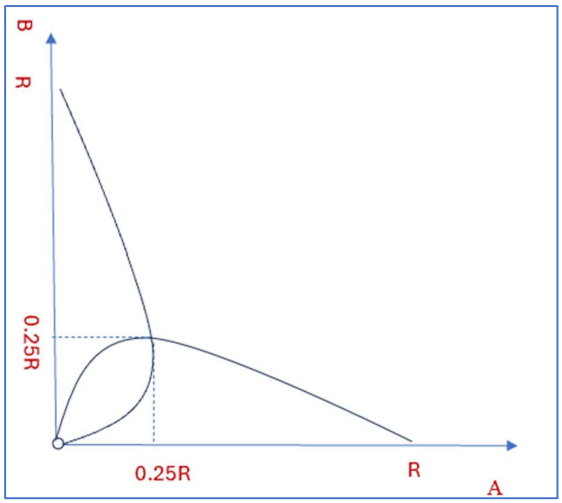

Figure 2: BRF's of both contestants and their intersection (NE)
Source: Authors' own graph based on equations (5) and (6)

The only intersection and the only Nash equilibrium is where A as well as B invests an amount equal to one fourth (0.25) of the rent.

This meets the condition for a NE: Once contestant A observes that contestant B invests one fourth of the rent, he is not motivated to invest any other amount. The same applies to contestant B, so the intersection at A=B=0.25R is the only Nash equilibrium of the model.

There is no intersection at A=B=0, because of the condition given below equation (2). If any contestant invested zero, the other one would be motivated to invest any small amount and gain everything. Because the model is not defined for both investments being zero, the point [0;0], which only seemingly looks as another intersection, is indicated by an empty disc in Fig. 2.

5. APPLICATIONS OF THE TULLOCK CONTEST

5.1. Political advertising as a Tulloc contest prisoner's dilemma

To illustrate how useful the Tullock contest can be, we will connect the topic of equilibrium in the Tullock contest with the prisoner's dilemma in an example of political advertising.

Assume a two-party political system with Party A and Party B seeking for the votes. If the parties do not cooperate, each spends a huge amount (50 million dollars) on campaigning. Assume that political parties gain after the election 100 dollars per vote from the government. For the matter of simplicity assume that there are no other benefits or costs for the political parties associated with being elected. If the parties spend equal amounts on political advertising, their chances to gain votes are equal and the votes will split approximately evenly between them. Assume that there are 2 million voters, so each party can expect to gain 1 million votes if the investments in political campaigns are equal. If each spends 50 million and each gains 1 million votes, the revenue of each will be 100 million dollars and expenditure 50 million dollars resulting in a profit of 50 million dollars. Assume that political parties agreed to limit advertising expenditure to 30 million dollars. If both comply (cooperate) the votes will split evenly again, but thanks to lower expenditure the profit of each will be as much as 70 million dollars. Assume that if one complies while the other one does not (defect), the one spending more will gain additional 0.25 million votes at the expense of the one that cooperates so the one that defects gains in total 1.25 million votes while the one that cooperates gains just 0.75 million votes. This results in a profit of 75 million dollars for the defecting party and 45 million dollars for the cooperating party.

This situation constitutes a prisoner's dilemma with the dominant strategy to defect for each party as shown in Table 1.

Table 1: The payoff matrix – election game

A; B	**Cooperate (spends 30 mil.)**	**Defect (spends 50 mil.)**
Cooperate (spends 30 mil.)	70; 70	45; 75
Defect (spends 50 mil.)	75; 45	50; 50

Source: Authors' own illustration

Similar examples of prisoner's dilemma in game theoretical literature merely mention that defection means spending more. With the knowledge of the Tullock contest we are, however, able to say how much exactly defectors tend to spend.

In fact, in our example, the amount of 50 million dollars was not chosen arbitrarily as "a high amount spent when defecting". It is the result of applying the Tullock contest. The rent is equal to 100 dollars per vote times the pool of 2 million votes which gives 200 million dollars. From equation (1) we know that optimal investment is one quarter of the rent, which is 50 million in this example.

This approach has far-reaching implications. The traditional application of Prisoner's dilemma explains *why* political parties and oligopolist firms invest large amounts of money in advertising. The Tullock contest explains *how* much they exactly tend to spend. The

traditional prisoner's dilemma explains *why* trees in a rainforest grow tall when they could get the same amount of sunlight with less growth and less energy. The Tullock contest explains *how* far the trees will grow in equilibrium. The traditional prisoner's dilemma explains *why* countries invest many lives of soldiers and huge amounts of money in weapons when the war front does not change for years, and they could achieve the same territorial losses and gains by agreeing to a ceasefire without losses of lives and money. The Tullock contest explains *how* much exactly the warring parties will tend to invest in fighting each other. The traditional prisoner's dilemma explains *why* people talk loudly at a party when they would be able to hear each other in the same quality at normal voice level with much less energy expended. The Tullock contest explains *how* loudly people will talk at a party. The traditional prisoner's dilemma explains *why* dinosaurs grew to giant sizes when their fighting strength would be balanced at a smaller size and with less energy expended. The Tullock contest explains *what* equilibrium sizes they would reach.

5.2. Prisoner's dilemma in environmental policy which is not a Tullock contest

Not every prisoner's dilemma can by analysed as a Tullock contest. Take an example of air pollution agreements.

International treaties in general are typical examples where the concept of prisoner's dilemma can be applied, because they include no enforcement mechanisms. Therefore, the choice for each party is to cooperate or to defect.

Consider a situation of two countries, A and B, concluding a treaty under which they shall reduce air pollution by various measures, such as regulation or an emission trading mechanism, because they believe that the benefits would exceed the costs of these measures.

Let us assume that the emission of CO_2 causes global warming which is costly in terms of damages caused by draught and fires. The benefit for each country can be measured in terms of the reduction of damages. The more money countries invest in renewable energy the more they reduce emissions, and the more they benefit in terms of the reduction of possible damages.

In this case, the payoff function of each player depends on the sum rather than on the proportion of the investments of the two players. The profit function of country A can be defined as

$$\pi_A = \frac{c}{2}(A + B) - A$$

rather than $\pi_A = \frac{R \cdot A}{A+B} - A$ as in equation (3), which means that this example is a prisoner's dilemma but not a Tullock contest.

Assume, for instance, that the countries believe that total benefits are 20% greater than the costs when countries cooperate (i.e. parameter c in the equation above equals 1.2). That is why they have concluded the treaty. If both cooperate and both invest $A = B = 100$, each gains half of $1.2(100 + 100)$ at a cost of 100 which yields a payoff of 20. If one invests 100 while the other invests nothing, the one which invests gains half of $1.2(100 + 0)$ at a cost of 100 which yields a payoff of -40, and the one which invests nothing (free-rides) gains half of $1.2(0 + 100)$ at a cost of 0 which yields a payoff of 60.

This situation constitutes a prisoner's dilemma with the dominant strategy to defect for each country as shown in Table 4.

Table 2: The payoff matrix – environmental treaty game

A; B	Cooperate (reduce emissions)	Defect (do not reduce emissions)
Cooperate (reduce emissions)	20; 20	-40; 60
Defect (do not reduce emissions)	60; -40	0; 0

Source: Authors' own illustration

The example above shows that international environmental agreements are not characterized as Tullock contests, thus prisonner's dilemma game in these cases ends up in a defect-defect Nash equilibrium with an investment of zero and a payoff of zero for each player. Shortly, the players will tend to free ride. Treaties like this can work only if some sort of enforcement is available or if a country involved is so large so that its share in global benefits exeeds its own expenditure.

6. DISCUSSION

Using a simplified example of two contestants this paper provides an analytical framework for predicting agents' behavior using game theory. In practice, there are often multilateral games, such as an election campaign with more than two political parties or a treaty between more than two countries. It should be noted that the model can be easily extended to more players and we only did not provide the corresponding equations for more than two players for the matter of simplicity. The general conclusions of the model hold also for the case of more players.

This paper provides only mathematical derivation of the model without providing testing in on data. This opens an opportunity for further research. Data of advertising expenditure spent by political parties or by oligopolist firms or data of military expenditure of warring countries could be gathered and a hypothesis that the expenditure will correspond to the equilibrium provided by the model could be tested. Further research can aim at testing the model on the real data.

Tullock had expressed concerns that actual expenditure of the firms (on lobbying) is significantly smaller than what the model would suggest. This is discussed in literature as the Tullock paradox. In lobbying, much of the expenditure can be hidden and testing would face limitations. This is another reason why further research should deal with commercial advertising rather than with lobbying. Possible explanations of the Tullock paradox can also be discussed in further research.

7. CONCLUSION

As we have shown, some prisoner dilemmas are Tullock contests (such as advertising) and some are not (such as environmental agreements).

In specific cases where the share in total revenues for each player or the probability a player gains some revenue depends on the proportion of the investments of individual

players, game theory provides the equilibrium amount to be invested and the resulting profit.

We have applied standard concepts of game theory such as the best-response functions, prisoner's dilemma, dominant strategy equilibrium and the Nash equilibrium to thoroughly explain the Tullock contest. We have provided an analytical framework for predicting the behaviour of people, firms or countries and their investments and payoffs in situations such as lobbying, advertising, wars and others.

By providing two illustrative examples, one of political advertising and one of environmental treaties, we have shown that two types of Prisoners' dilemmas can be distinguished: Prisoners' dilemmas that are Tullock contests and Prisoners' dilemmas that are not Tullock contests, depending on the character of the payoff function.

Funding: This research was funded by University of Finance and Administration, Czech Republic.

REFERENCES

[1] J. von Neumann and O. Morgenstern, *The Theory of Games and Economic Behavior*, 2nd ed. Princeton, NJ, USA: Princeton University Press, 1947.

[2] J. F. Nash, "Non-cooperative games," *Econometrica*, Annals of Mathematics, Princeton, NJ, vol. 54, no. 2, 1951. [Online]. Available: https://libraries.mit.edu/150books/2011/04/07/1951/

[3] A. A. Cournot and I. Fisher, *Researches Into the Mathematical Principles of the Theory of Wealth*, London, U.K.: Macmillan, 1897.

[4] M. J. Osborne, *An Introduction to Game Theory*, New York, NY, USA: Oxford University Press, 2004.

[5] R. Gibbons, *A Primer in Game Theory*, Harlow, U.K.: Prentice Hall, 1992.

[6] E. Buzila, "The Emergence of the Tullock-Contest," *Bargaining Theory eJournal*, Nov. 2019.

[7] E. Sadik-Zada, "Game theory applications to socio-environmental studies, development economics, and sustainability research," *Games*, vol. 15, no. 1, p. 5, 2024, doi: 10.3390/g15010005.

[8] U. Sumaila, A. Dinar, and J. Albiac, "Game theoretic applications to environmental and natural resource problems," *Environment and Development Economics*, vol. 14, no. 1, pp. 1–5, 2009, doi: 10.1017/s1355770x08004609.

[9] T. Yang, H. Liao, and Y. Du, "A dynamic game modeling on air pollution mitigation with regional cooperation and non-cooperation," *Integrated Environmental Assessment and Management*, vol. 19, no. 6, pp. 1555–1569, 2023, doi: 10.1002/ieam.4766.

[10] Z. Zhou, H. Feng, H. Wang, and K. Wang, "Influence of heterogeneous environmental regulation policies on the strategy of pollutant discharge for enterprise: an evolutionary game approach," *Environmental Research Communications*, vol. 4, no. 9, 2022, doi: 10.1088/2515-7620/ac897.

[11] C. Tapiero, "Environmental quality control and environmental games," *Environmental Modeling & Assessment*, vol. 9, no. 4, pp. 201–206, 2005, doi: 10.1007/s10666-005-2451-4.

[12] J. Chen, "Exploring the role and mechanisms of environmental serious games in promoting pro-environmental decision-making: a focused literature review and future research agenda," *Frontiers in Psychology*, vol. 15, 2024, doi: 10.3389/fpsyg.2024.1455005.

[13] J. Hoegg and M. Lewis, "The impact of candidate appearance and advertising strategies on election results," *Journal of Marketing Research*, vol. 48, no. 5, pp. 895–909, 2011, doi: 10.1509/jmkr.48.5.895.

[14] A. O'Cass, "Political advertising believability and information source value during elections," *Journal of Advertising*, vol. 31, no. 1, pp. 63–74, 2002, doi: 10.1080/00913367.2002.10673661.

[15] K. Goldstein and P. Freedman, "Campaign advertising and voter turnout: new evidence for a stimulation effect," *The Journal of Politics*, vol. 64, no. 3, pp. 721–740, 2002, doi: 10.1111/0022-3816.00143.

[16] K. Goldstein and P. Freedman, "New evidence for new arguments: money and advertising in the 1996 senate elections," *The Journal of Politics*, vol. 62, no. 4, pp. 1087–1108, 2000, doi: 10.1111/0022-3816.00047.

[17] G. Duggal, "The dynamics of political advertising: a comprehensive theoretical analysis," *Journal of Communication and Management*, vol. 2, no. 4, pp. 275–280, 2023, doi: 10.58966/jcm20232410.

[18] J. Dermody and R. Scullion, "Facing the future: young people's awareness of the 2001 British general election advertising campaigns," *Journal of Public Affairs*, vol. 3, no. 2, pp. 152–165, 2003, doi: 10.1002/pa.143.

[19] D. Stevens, J. Sullivan, B. Allen, and D. Alger, "What's good for the goose is bad for the gander: negative political advertising, partisanship, and turnout," *The Journal of Politics*, vol. 70, no. 2, pp. 527–541, 2008, doi: 10.1017/s0022381608080481.

[20] G. Huber and K. Arceneaux, "Identifying the persuasive effects of presidential advertising," *American Journal of Political Science*, vol. 51, no. 4, pp. 957–977, 2007, doi: 10.1111/j.1540-5907.2007.00291.x.

[21] A. Prat, "Campaign advertising and voter welfare," *The Review of Economic Studies*, vol. 69, no. 4, pp. 999–1017, 2002, doi: 10.1111/1467-937x.00234.

[22] E. Fowler, L. Baum, E. Jesch, D. Haddad, C. Reyes, S. Gollust, and J. Niederdeppe, "Issues relevant to population health in political advertising in the United States, 2011–2012 and 2015–2016," *Milbank Quarterly*, vol. 97, no. 4, pp. 1062–1107, 2019, doi: 10.1111/1468-0009.12427.

[23] J. Newell, "Political advertising saturation in the 2016 Iowa caucuses," *Journal of Political Marketing*, vol. 21, no. 1, pp. 1–22, 2018, doi: 10.1080/15377857.2018.1513384.

[24] B. Gordon and W. Hartmann, "Advertising competition in presidential elections," *SSRN Electronic Journal*, 2013, doi: 10.2139/ssrn.2322901.

[25] K. Goldstein and T. Ridout, "Measuring the effects of televised political advertising in the United States," *Annual Review of Political Science*, vol. 7, no. 1, pp. 205–226, 2004, doi: 10.1146/annurev.polisci.7.012003.104820.

[26] D. Stevens, "Separate and unequal effects: information, political sophistication and negative advertising in American elections," *Political Research Quarterly*, vol. 58, no. 3, pp. 413–425, 2005, doi: 10.1177/106591290505800304.

[27] D. Stevens, "The relationship between negative political advertising and public mood: effects and consequences," *Journal of Elections, Public Opinion and Parties*, vol. 18, no. 2, pp. 153–177, 2008, doi: 10.1080/17457280801987876.

[28] T. Ridout, E. Fowler, F. Michael, and K. Goldstein, "The long-term and geographically constrained effects of campaign advertising on political polarization and sorting," *American Politics Research*, vol. 46, no. 1, pp. 3–25, 2017, doi: 10.1177/1532673x17721479.

[29] F. Michael, "The utility and content of traditional ads," pp. 201–223, 2019, doi: 10.1093/oxfordhb/9780190860806.013.30.

[30] J. Brandon and Y. Yook, "Political uncertainty and corporate investment cycles," *The Journal of Finance*, vol. 67, no. 1, pp. 45–83, 2012, doi: 10.1111/j.1540-6261.2011.01707.x.

[31] A. Gerber, J. Gimpel, D. Green, and D. Shaw, "How large and long-lasting are the persuasive effects of televised campaign ads? Results from a randomized field experiment," *American Political Science Review*, vol. 105, no. 1, pp. 135–150, 2011, doi: 10.1017/s000305541000047x.

[32] C. Robinson, "Political advertising and the demonstration of market orientation," *European Journal of Marketing*, vol. 44, no. 3/4, pp. 451–460, 2010, doi: 10.1108/03090561011020525.

[33] B. Silveira and J. Mello, "Campaign advertising and election outcomes: quasi-natural experiment evidence from gubernatorial elections in Brazil," *The Review of Economic Studies*, vol. 78, no. 2, pp. 590–612, 2011, doi: 10.1093/restud/rdq012.

[34] J. Sides, L. Vavreck, and C. Warshaw, "The effect of television advertising in United States elections," *American Political Science Review*, vol. 116, no. 2, pp. 702–718, 2021, doi: 10.1017/s000305542100112x.
[35] A. Barfar and B. Padmanabhan, "Does television viewership predict presidential election outcomes?," *Big Data*, vol. 3, no. 3, pp. 138–147, 2015, doi: 10.1089/big.2015.0008.
[36] M. Scammell and A. Langer, "Political advertising: why is it so boring?," *Media, Culture & Society*, vol. 28, no. 5, pp. 763–784, 2006, doi: 10.1177/0163443706067025.
[37] X. Zhou and G. Wodtke, "Residual balancing: a method of constructing weights for marginal structural models," *Political Analysis*, vol. 28, no. 4, pp. 487–506, 2020, doi: 10.1017/pan.2020.2.
[38] M. Gupta, "Negative political advertising: some effects from the 13th Indian general election 1999," *Global Business Review*, vol. 1, no. 2, pp. 249–277, 2000, doi: 10.1177/097215090000100206.
[39] N. Valentino, "The impact of political advertising on knowledge, internet information seeking, and candidate preference," *Journal of Communication*, vol. 54, no. 2, pp. 337–354, 2004, doi: 10.1093/joc/54.2.337.
[40] A. Lawlor and E. Crandall, "Understanding third-party advertising: an analysis of the 2004, 2006 and 2008 Canadian elections," *Canadian Public Administration*, vol. 54, no. 4, pp. 509–529, 2011, doi: 10.1111/j.1754-7121.2011.00190.x.
[41] T. Ridout and E. Fowler, "Explaining perceptions of advertising tone," *Political Research Quarterly*, vol. 65, no. 1, pp. 62–75, 2010, doi: 10.1177/1065912910388189.
[42] A. Ter-Mkrtchyan and A. Franklin, "Global financial system outcomes after 2008: a longitudinal comparison," *Economies*, vol. 8, no. 1, p. 24, 2020, doi: 10.3390/economies8010024.
[43] M. Bolívar, A. Galera, M. Subirés, and L. Muñoz, "Analysing the accounting measurement of financial sustainability in local governments through political factors," *Accounting, Auditing & Accountability Journal*, vol. 31, no. 8, pp. 2135–2164, 2018, doi: 10.1108/aaaj-10-2016-2754.
[44] N. Ellili, "Impact of corporate governance on environmental, social, and governance disclosure: any difference between financial and non-financial companies?," *Corporate Social Responsibility and Environmental Management*, vol. 30, no. 2, pp. 858–873, 2022, doi: 10.1002/csr.2393.
[45] H. Voghouei, M. Azali, and S. Law, "Does the political institution matter for financial development?," *Journal of Applied Economics and Policy*, vol. 30, no. 1, pp. 77–98, 2011, doi: 10.1111/j.1759-3441.2011.00095.x.
[46] A. Maaloul, R. Chakroun, and S. Yahyaoui, "The effect of political connections on companies' performance and value," *Journal of Accounting in Emerging Economies*, vol. 8, no. 2, pp. 185–204, 2018, doi: 10.1108/jaee-12-2016-0105.
[47] Hadiputra, "Political connection, financial distress and cost of debt: empirical evidence from emerging country," *Jurnal Manajemen Teori dan Terapan*, vol. 16, no. 2, pp. 368–380, 2023, doi: 10.20473/jmtt.v16i2.44853.
[48] J. Ang, D. Ding, and T. Thong, "Political connection and firm value," *Asian Development Review*, vol. 30, no. 2, pp. 131–166, 2013, doi: 10.1162/adev_a_00018.
[49] M. Sadiq, S. Mohamad, and W. Kwong, "Do CEO incentives mediate the relationship between political influences and financial reporting quality?," *International Journal of Asian Social Science*, vol. 9, no. 3, pp. 276–284, 2019, doi: 10.18488/journal.1.2019.93.276.284.
[50] H. Toroyan and G. Anayiotos, "Institutional factors and financial sector development: evidence from Sub-Saharan Africa," *IMF Working Paper*, no. 09/258, p. 1, 2009, doi: 10.5089/9781451874044.001.
[51] F. Song and A. Thakor, "Notes on financial system development and political intervention," *The World Bank Economic Review*, vol. 27, no. 3, pp. 491–513, 2012, doi: 10.1093/wber/lhs011.
[52] N. Herger, R. Hodler, and M. Lobsiger, "What determines financial development? Culture, institutions or trade," *Review of World Economics*, vol. 144, no. 3, pp. 558–587, 2008, doi: 10.1007/s10290-008-0160-1.

[53] S. McGuire, T. Omer, and N. Sharp, "The impact of religion on financial reporting irregularities," *The Accounting Review*, vol. 87, no. 2, pp. 645–673, 2011, doi: 10.2308/accr-10206.
[54] N. Netshakhuma, "The implications of political party funding act, no. 6 of 2018 in South Africa on records management," *Global Knowledge, Memory and Communication*, vol. 70, no. 4/5, pp. 293–303, 2020, doi: 10.1108/gkmc-02-2020-0014.
[55] M. Kholmi, "Persepsi konstituen terhadap akuntabilitas keuangan partai politik (studi di kota Malang)," *Jurnal Akuntansi Multiparadigma*, 2010, doi: 10.18202/jamal.2010.08.7089.
[56] S. Gherghina and M. Chiru, "Taking the short route," *East European Politics, Societies and Cultures*, vol. 27, no. 1, pp. 108–128, 2012, doi: 10.1177/0888325412465003.
[57] A. Ufen and M. Mietzner, "Political finance regimes in Southeast Asia: introduction," *Critical Asian Studies*, vol. 47, no. 4, pp. 558–563, 2015, doi: 10.1080/14672715.2015.1082260.
[58] M. Nishikawa, "Electoral and party system effects on ruling party durability," *Party Politics*, vol. 18, no. 5, pp. 633–652, 2011, doi: 10.1177/1354068810389633.
[59] V. Randall and L. Svåsand, "Party institutionalization in new democracies," *Party Politics*, vol. 8, no. 1, pp. 5–29, 2002, doi: 10.1177/1354068802008001001.
[60] E. Wegner, "Local-level accountability in a dominant party system," *Government and Opposition*, vol. 53, no. 1, pp. 51–75, 2016, doi: 10.1017/gov.2016.1.
[61] G. Tullock, "On the efficient organization of trials," *Kyklos*, vol. 28, no. 4, pp. 745–762, 1975.
[62] G. Tullock, "Efficient rent seeking," in *Toward a Theory of the Rent-Seeking Society*, J. M. Buchanan, R. D. Tollison, and G. Tullock, Eds., College Station, TX, USA: Texas A&M University, 1980.
[63] J. D. D. Little, "Aggregate advertising response models: The state of the art," Sloan School of Management, MIT Working Paper 1048-79, 1979.