Application of the graph model for conflict resolution in the truck driver strike in Brazil: a Case Study

Aplicação do modelo gráfico para resolução de conflitos na greve dos caminhoneiros no Brasil: um estudo de caso

DOI:10.34117/bjdv9n2-130

Recebimento dos originais: 23/01/2023
Aceitação para publicação: 22/02/2023

Hugo Victor Silva
Master in Modeling and Quantitative Methods
Institution: Universidade Federal de Pernambuco
Endereço: Av. Prof. Moraes Rego, 1235, Cidade Universitária, Recife – PE, CEP: 50670-901
E-mail: hugo.silva@ifce.edu.br

João Marcos Menezes Viana
Graduating in Mathematics
Institution: Instituto Federal de Educação, Ciência e Tecnologia do Ceará
Address: Av. Treze de Maio, 2081, Benfica, Fortaleza – CE,
CEP: 60040-531
E-mail: marcos.viana@gdppi.ifce.edu.br

Miguel Victor Freire de Carvalho
Graduating in Mathematics
Institution: Instituto Federal de Educação, Ciência e Tecnologia do Ceará
Address: Av. Treze de Maio, 2081, Benfica, Fortaleza – CE,
CEP: 60040-531
E-mail: marcos.viana@gdppi.ifce.edu.br

Virgílio Moura Queiroz
Graduated in Computer Networking
Institution: Instituto Federal de Educação, Ciência e Tecnologia do Ceará
Address: Rodovia BR 020, Km 303, S/N, Jubaia, Canindé – CE,
CEP: 62700-000
E-mail: virgilio.moura.queiroz06@aluno.ifce.edu.br

Rubens Abraão da Silva Sousa
Graduating in Systems Analysis and Development
Institution: Instituto Federal de Educação, Ciência e Tecnologia do Ceará
Address: Rodovia BR 020, Km 303, S/N, Jubaia, Canindé – CE,
CEP: 62700-000
E-mail: rubens.sousa@gdppi.ifce.edu.br

ABSTRACT
One of the most stressful human interactions is conflict. In some cases, it can bring high losses even to parties that are not involved in the conflict. A possible scenario for resolving the conflict can be found using a Graph Model for Conflict Resolution (GMCR)

which is a tool used to analyze conflicts and present scenarios that can be seen as possible solutions to the conflict. Considering several stability criteria, in this work, we present a case study: the historical background, the modeling using the GMCR and the stable states according to the presented criteria of a conflict that occurred in Brazil, where truck drivers went on strike and generated damages to the population such as a supply crisis (of food, medicines, fuel, among other products) and financial losses to the government (delay in the flow of goods, crowding of ports, among others), mainly in cities far from large urban centers and in centers for the flow of goods by road.

Keywords: graph model for conflict resolution (GMCR), stability, supply crisis.

RESUMO
Uma das interações humanas mais estressantes é o conflito. Em alguns casos, pode trazer altas perdas até´ mesmo para as partes que não estão envolvidas no conflito. Um possível cenário para a resolução do conflito pode ser encontrado utilizando um Modelo Gráfico para Resolução de Conflitos (GMCR) que é uma ferramenta usada para analisar conflitos e apresentar cenários que possam ser vistos como possíveis soluções para o conflito. Considerando diversos critérios de estabilidade, neste trabalho, apresentamos um estudo de caso: o retrocesso histórico, a modelagem utilizando o GMCR e os estados estáveis de acordo com os critérios apresentados de um conflito ocorrido no Brasil, onde os caminhoneiros entraram em greve e geraram danos à população, como uma crise de abastecimento (de alimentos, medicamentos, combustível, entre outros produtos) e prejuízos financeiros ao governo (atraso no escoamento de mercadorias, lotação de portos, entre outros), principalmente em cidades distantes dos grandes centros urbanos e em centros de escoamento de mercadorias por estrada.

Palavras-chave: modelo gráfico para resolução de conflitos (GMCR), estabilidade, crise de abastecimento.

1 INTRODUCTION

Conflicts are common in humans, whether they are professional relationships, commercial, diplomatic, love relationships, among others. These problems can generate strain on the relationship and even on parties not directly related to any conflict. A labor category, when demanding better working conditions and better wages, conflicts with its employer in the form of a strike, causing a reduction in the company's production and income. In the case of self-employed workers, who work on their own, it is more difficult to obtain better working conditions and better wages because they do not have an employer.

In Brazil, the flow of goods is primarily done by road, making the country dependent on roads in good condition, affordable fuel prices and truck drivers willing to travel long distances in an efficient manner. A truck drivers' strike would be harmful to the supply of food and medicines in cities far from major production centers and ports,

which would force the national government to take measures to meet the demands of truck drivers.

With articulation through social networks, a movement at national level was started with the objective of uniting the category with common goals and, as their demands were not met, on May 21, 2018, the truck drivers strike began in Brazil. The causes of this event are related to the rampant adjustments in the price of diesel, the collection of tolls per suspended axle and the PIS/Cofins tax on diesel. The precedents of this strike came a little earlier, between 2009 and 2015, in which, according to some economists, the BNDES program on Support and Investment, would be one of the factors responsible for starting this strike. The purpose of this program would be to increase the truck fleet in Brazil, but with this increase there was a large drop in freight prices, in this scenario, truckers began to have more difficulties to cope with the increase in fuel. And so, in 2018, the truckers' union leaders (Abcam, CNTA, Unicam and the Autonomous Truckers) met and decided to start a strike throughout Brazil, blocking most highways with their trucks.

Amid the outage, participants demanded a reduction in the price of diesel, improvements in work, exemption in the toll rate and minimum definition for the price of freight. However, the federal government did not immediately meet the strikers' demands and, as a consequence, many activities that depended on the transportation carried out by the sector were impaired. With roadblocks, many states such as Brasilia have increased gasoline prices, shortages of food and medicine, as well as canceled flights and a reduction in bus fleet. With Brazil stagnant amid the strike, Petrobras lost significant shares in the stock market and the company's value fell by 137 billion in the market, already in relation to public coffers, Fabio Kanczuc, Secretary of Economic Policy of the Ministry of Finance, said there was a loss of 15 billion to the economy, but Kanczuc defined the account as "conservative", for disregarding other sectors.

The objective of this research is to present to the reader a case study where the Graph Model for Conflict Resolution will be applied, which constitutes a model to formally and systematically study conflicts and, in this case, we have a conflict located in a country with a large territorial extension and that entails social losses, generating a supply crisis and financial losses, both for commerce and for the government, since we would have a considerable reduction in tax collections. A conflict stability analysis will be carried out, and the equilibrium states will be presented according to the classic criteria of the GMCR.

2 REVIEW OF THE LITERATURE

This section seeks to recall the theoretical foundation that will be used to treat the theme throughout the paper. In Subsection 2.1 we recall the concepts presented by Kilgour et al. (1987) for the GMCR model, while in Subsection 2.2, we present five of the classical stability definitions used in this model.

2.1 THE GRAPH MODEL FOR CONFLICT RESOLUTION

We now briefly present how a conflict can be modeled using the GMCR representation. First, we identify the parties involved in a conflict, called decision makers (DMs), we can then identify actions that may or may not be taken by DMs throughout a conflict. Thus, it is possible to derive all possible conflict states, which gives a complete description of every DM's options. Then, we identify the unfeasible states, which represent either mutually exclusive DM's options or do not make sense in the conflict context. Excluding these states, viable states will be represented by vertices of graphs in the GMCR. The arcs in each graph in the GMCR represent state changes that can be made by DMs if they decide to take or not some option. Finally, we need to determine a binary preference relation for each DM over the set of viable conflict states. This is the end of the modeling phase.

Once the conflict parameters have been identified, an analysis from the perspective of each DM may be done to determine if there is incentive to move away from a given state or not according to some stability concept. Finally, a state is said to be an equilibrium according to some stability concept if it satisfies that stability concept for all DMs.

Formally, let $N = \{1, 2, \dots, n\}$ be the set of DMs involved in the conflict. $S = \{1, 2, \dots, m\}$ represents the set of viable conflict states of the conflict and are described as vertices of a graph. A finite collection of directed graphs, $D_i = \{S, A_i\},\ i \in N$, can be used to model the course of a conflict, where $A_i \subseteq S \times S$. In the graph D_i, an arc $(a, b) \in A_i$ exists between states $a, b \in S$ if and only if DM i can move unilaterally (in one step) from state a to state b. The graph is called directed because the arc has an orientation that can be one way (irreversible move) or two ways (reversible move). The preference relation of DM i is a binary relation, $\{\succ_i\}$, over S, where $a \succ_i b$ means the DM i strictly prefers state a to state b. It is assumed that $\succ_i$ is asymmetric, i.e., $a \succ_i b$ implies that $b \nsucc_i a$ and irreflexive, i.e., $a \nsucc_i a$ for every state a. From the binary relation

$\succ_i$, one can derive two other binary relations $\succsim_i$ and $\sim_i$. We say $a \succsim_i b$ when $b \nsucc_i a$, which is called weak preference relation, while $a \sim_i b$ if $a \nsucc_i b$ and $b \nsucc_i a$, which is called indifference relation. Strict ordinal preferences mean that there is no indifference between states. In general, no assumption of preference transitivity is made in the model.

For each $i \in N$ and for each state$s \in S$, $R_i(s)$ is the set of all states that DM i can move to (in one step) from state s, formally defined by:

$$R_i(s) = \{a \in S : (s, a) \in A_i\} \qquad (1)$$

We assume, as usual in the GMCR literature, that s∉R_i (s), ∀_s∈S. For the definition of stability concepts, let us define a subset of R_i (s), denoted by R_i^+ (s), which is the set of all states to which DM i can move (in one step) from state s which are strictly preferable to state s, formally defined by:

$$R_i^+(s) = \{a \in R_i(s) : a \succ_i s\} \qquad (2)$$

The one-step move by DM i from state s to state a in R_i (s) is called a Unilateral Move while the one-step move by DM i from state s to state a∈R_i^+ (s) is called a Unilateral Improvement.

2.2 GMCR STABILITY CONCEPTS

The main objective of the GMCR is to predict or evaluate the stability/equilibrium of each state for each DM. Five of the classic solution concepts according to which a state can be stable are: Nash Stability or Rationality (R) Nash (1950), General Metarationality (GMR) Howard (1971), Sequential Stability (SEQ) FRASER e HIPEL (1979), Symmetric Metarationality (SMR) Howard (1971) and Symmetric Sequential Stability (SSEQ) Rêgo e Vieira (2016). In what follows, we recall their formal definitions for bilateral conflicts.

(Nash (R) Stability) State $s \in S$ is Nash stable for DM $i \in N$ if and only if $R_i^+(s) = \emptyset$.

(General Metarational Stability (GMR)) State $s \in S$ is GMR stable for DM $i \in N$ if and only if for each state $a \in R_i^+(s)$ there is at least one state $b \in R_j(a)$ such that $s \succsim_i b$.

(Symmetric Metarational Stability (SMR)) State $s \in S$ is SMR stable for DM $i \in N$ if and only if for each state $a \in R_i^+(s)$ there is at least one state $b \in R_j(a)$ such that $s \succsim_i b$ and $s \succsim_i c$ for every state $c \in R_i(b)$.

(Sequential Stability (SEQ)) State $s \in S$ is SEQ stable for DM $i \in N$ if and only if for each state $a \in R_i^+(s)$ there is at least one state $b \in R_j^+(a)$ such that $s \succsim_i b$.

(Symmetric Sequential Stability (SSEQ)) State $s \in S$ is (SSEQ) stable for DM $i \in N$ if and only if for every state $a \in R_i^+(s)$ is there at least one state $b \in R_j^+(a)$ such that $s \succsim_i b$ and $s \succsim_i c$ for every state $c \in R_i(b)$.

3 CONTEXT

The truckers' strike in Brazil was a stoppage of autonomous truckers of national level started on May 21, 2018, during the government of Michel Temer, and ending on May 30, 2018, after intervention by the Brazilian army force and Federal Highway Police (PRF), which despite having been triggered, served only to guide the trucks to unlock the highways (SATRIANO, 2018). The start of the strike was due to the dissatisfaction of drivers against diesel, where Petrobras made its fifth adjustment in fuel prices on May 19, increasing diesel by 0,80% and gasoline by 1,34% in refineries, with 8,2% increasing for consumers from January to May. During the eve of the truckers' strike the diesel was R$ 3,60 for the consumer and R$ 2,35 at the refinery (JASPER, 2021).

The federal court, in response to the threats of the strike, prohibits the total blockade on federal roads by truckers in Parana´, otherwise they would have to pay a fine of 100 thousand reais per hour. This action was filed by the Attorney General of the Union (AGU) at the request of the PRF Superintendence. On May 21, the truckers stopped, with the first blockades taking place, in the meantime the Ministry of Mines and Energy said that Temer would meet with the other ministers in the Plateau with the aim of bringing a forecast on the rise of fuels [Fernandes, 2018]. On the 22nd of the same month, the stoppage has even higher proportions and now reaches 24 states. Petrobras announces reduction in prices in refineries and the Minister of Finance, Eduardo Guardia, informs that it will zero taxes on diesel by the year 2020 [G1, 2018]. On May 23, the President of the Republic called for a "truce" of two or three days to find a "satisfactory solution",

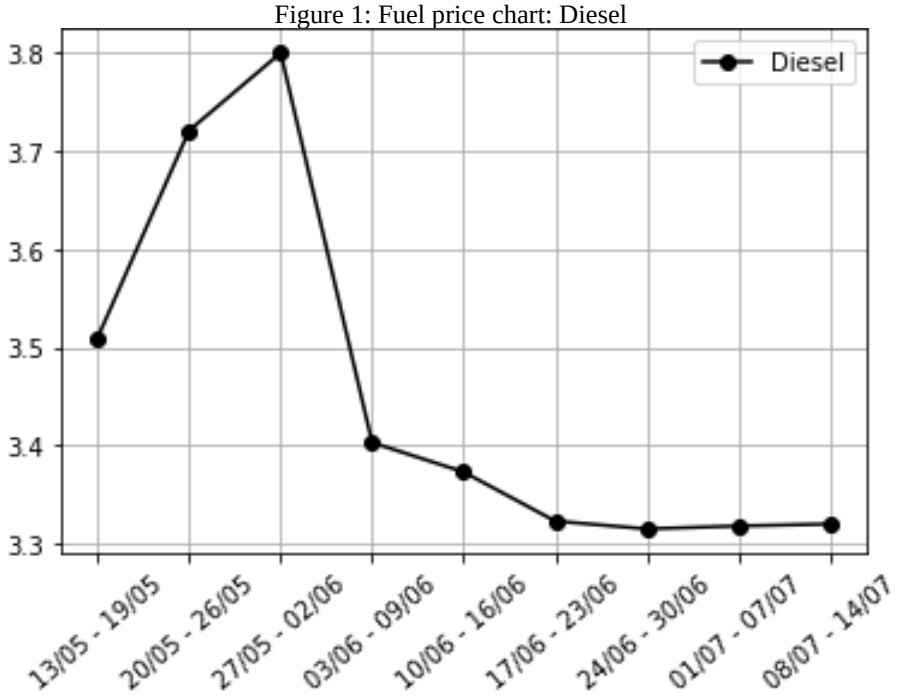
while diesel reaches R$ 2,34 in refineries (SATRIANO, 2018). On May 24, the Minister of the Civil House, Eliseu Padilha, announced that they had managed to reach an agreement and that they had suspended the national strike for 15 days (MAZUI, 2018). However, with the great delay in negotiations, many cities were already in need of several resources and on May 25, capitals such as: Rio de Janeiro, São Paulo and Rio Grande do Sul declared a state of emergency (SATRIANO, 2018).

Two entities representing the autonomous, the National Union of Truckers and the Brazilian Association of Truckers (ABCAM), do not corroborate the agreement, as they aimed not to readjust the price of diesel consecutively. In this way, Temer activates the Armed Forces by guaranteeing law and order to unlock the roads. On May 27, after a meeting with the ministers of the federal government, the president of the republic announced the reduction of R$ 0.46 the value of diesel, reaching R$3, 32 and stressed that this price would remain for about 60 days and that the adjustments would be carried out monthly and jointly. It also announced the minimum prices for freight and exemption from the payment of toll on suspended axle and, even so, the st (SATRIANO, 2018).

However, even with the length of the fuel reduction, other requirements such as the creation of a regulatory framework were not in the agreement proposed by the federal government to stop the shutdown. Thus, union leaders, such as the National Confederation of Autonomous Transporters (CNTA) and the Interstate Union of Autonomous Truckers, did not trust the agreement established and so the strike was prolonged until May 31, on this day, most states were without blockades or without protests on the roads, continuing only in the Port of Santos. On June 1st the strike ended in the Port of Santos (SATRIANO, 2018).

The following is a graph, in which the price of gasoline and diesel is recorded, before, during and after the trucker's stoppage.

Figure 1: Fuel price chart: Diesel



4 MODELING THE TRUCKS STRIKE CONFLICT

4.1 MODELING

In order to model the conflict, we will identify the decision makers and their respective options. In the conflict we observe that while truckers can remain on strike or not, the government may choose whether or not to meet the truckers' demands, whether they are the reduction of diesel.

In the following table we have a description of each decision maker's options. Because each option can be executed (s) or not executed (n), each combination of the options generates a conflict state with a total of 2 options, so we will have a total of 2^2 = 4 conflict states. The states will be listed in Table 1.

We can see based on table 2 above that in state (s_1), if the government met the truckers' claims, and yet, for a moment, the strike continued. Just as in the states, s_2 is also feasible, because they met the demands of truckers, and thus, the strike did not occur. The government did not meet the truckers' claim and the strike remained as shown in the s_3 state, i.e., it is a viable state. Looking at the table, we also see that the state s_4 is viable, because at the time when the Government does not approve the proposals of truckers, truckers did not maintain the strike.

Table 1: States of conflict.

DMs	Options	State 1	State 2	State 3	State 4
Government	1: Fulfill the claims	S	S	N	N
Truck drivers	2: Continue the strike	S	N	S	N

4.2 PREFERENCES

Based on the conflict states in table 1 it is possible to make the preferences of the decision makers according to the attributions of each state. The better that choice for the decision maker, the greater your preference for that state. So we can set the preferences of each decision maker.

The better the choice for the decision maker, the greater your preference for that state. So we can set the preferences of each decision maker. In this way, it will be of greater interest to truckers that the government meets the (O_1). Secondly, it is interesting for them to strike as long as the claims are not met, i.e. (¬O_1∧O_2). And finally, it is more advantageous for truckers not to strike (¬O_2), thus avoiding personal injury.

With regard to the other decision-making company, it will be more advantageous for the Government not to meet the demands and that there is no strike (¬O_1∧¬O_2). Secondly, it is interesting for the Government, if the truckers strike, do not meet the claims (¬O_1∧O_2), to try to negotiate the requests of truckers. And finally, it is advantageous for the Government to meet the claims, avoiding economic losses.

Thus, we can infer the preferences of truckers, where the state s_2 is the most preferable, because it meets the first criterion and the last, as well as the state s_1 is the second most preferable, because it meets the second criterion and the claims are met, the state s_3 is third preferable because it meets the second criterion but the claims were not met and the state s4 is the last because it meets only the third criterion. Thus the preferences of truckers: s_2≻s_1≻s_3≻s_4.

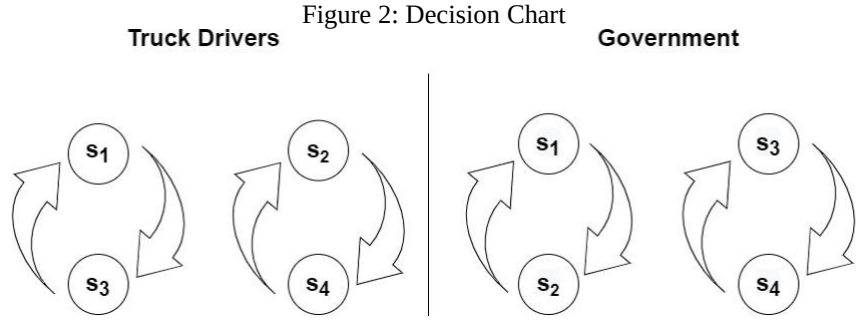
Thus, we can infer the preferences of the Government, where the state s_4 is the most preferable, because it meets the first criterion and the second, just as the state s_3 is the second most preferable, because it meets the second criterion, the state s_2 is third preferable because it meets the third criterion and the severe had its end, and state s_1 is the last because it meets only the third criterion. Thus the preferences of the Government: s_4≻s_3≻s_2≻s_1.

5 ACCESSIBILITY

In this conflict analysis, there is a set of graphs for the decision-makers involved,

where it has vertices, which would be the states of conflicts that move from one state to another through arcs, which would be the transitions that the decision maker can make. In the following figure we have the representation of the conflict through graphs, using vertices and arcs:

Figure 2: Decision Chart



Based on figure 2, we have that the walkers, for example, can be in the s_1 state, being able to switch to the s_2 state, as this decision maker is also in the s_3 state, it can continue in the s_3 state, or switch to the s_4 state.

Finally, we can say that the list of all states that truckers can go (R_C), are R_C (s_1)={s_2}, that is, only the s_2 state is accessible from the state s_1 for truckers, with this we have R_C (s_2)={s_1}, R_C (s_3)={s_4} and R_C (s_4)={s_3}. Already for the list of unilateral improvements R_C^+, where the decision maker goes to the most preferable state and continues in it, so we will have and R_C^+ (s1)={s_2}, R_C^+ (s_2)=Ø , R_C^+ (s_3)=Ø and R_C^+ (s_4)={s_3}.

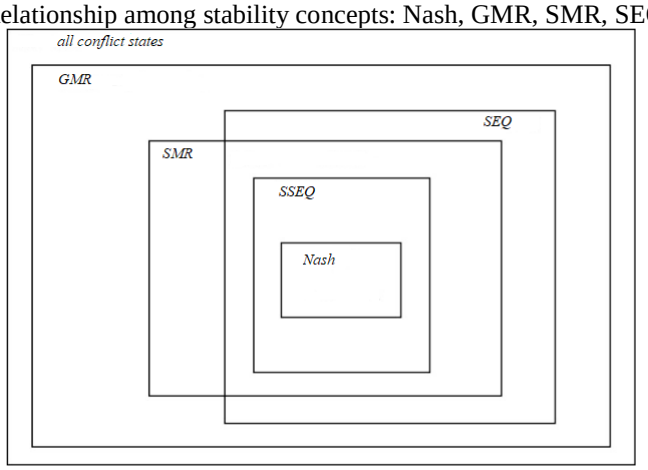
In the case of the Government, this decision maker may remain in the s_1 state, or switch to the s_3 state, or also the decision maker can choose to stay in the s¬_2 state, or switch to the s_4 state. If R_G is the list of states that the government can go to, we have R_G (s_1)={s_3}, R_G (s_3)={s_1}, R_G (s_2)={s_4} and R_G (s_4)={s_2}. For lists of unilateral improvements R_G^+ (s_1)={s_3}, R_G^+ (s_3)=Ø, R_G^+ (s_2)={s_4} and R_G^+ (s_4)=Ø.

6 STABILITY ANALYSIS

Based on what we have been presenting it is possible to arrive in a stable state for decision makers and if the state is stable for all it will be a state of equilibrium, but there are several concepts of stability, such as: General Methodal Stability, Sequential Stability, Symmetric Methodal Stability and Symmetric Sequential Stability. Already for the state of equilibrium we have the Nash Equilibrium. In the figure below, it is possible to observe

how the set of different conceptions of stability behaves:

Figure 3: Relationship among stability concepts: Nash, GMR, SMR, SEQ e SSEQ.



6.1 NASH EQUILIBRIUM

We can infer that a state is Nash stable for a decision maker if and only if the decision maker cannot unilaterally move to a more preferable state (NASH 1950). A state is Nash stable for the decision maker when the list of improvements of that state for that decision maker is the empty set, that is, R_d^+ (s)=Ø

Truck Drivers: $R_C^+(s_2) = \emptyset, R_C^+(s_3) = \emptyset$ (3)

Government: $R_G^+(s_3) = \emptyset, R_G^+(s_4) = \emptyset$ (4)

We can observe with the above results that the s_2 and s_3 states are stable Nash for the Truckers while the s_3 and s_4 states are stable Nash for the Government and with that we can conclude that the s_3 state is a Nash balance.

6.2 GENERATES METARATIONAL STABILITY (GMR)

The general metarrational stability aims to model the behavior of a focal decision maker who analyzes his possible movements based on the other decision maker, seeking to know in what situations the opponent can harm him even if it is not beneficial to that opponent (HOWARD, 1971). It is worth mentioning that the stable Nash state (s_3) is in the GMR.

6.2.1 Truck Drivers

$R_C^+(s_1) = \{s_2\} \longrightarrow R_G(s_2) = \{s_4\}$, being $s_1 \succ s_4$, for truckers, in this way it would be better to continue in the state s_1 and with that the state s_1 is GMR stable for this decision maker.

$R_C^+(s_4) = \{s_3\} \longrightarrow R_G(s_3) = \{s_1\}$, being $s_1 \succ s_4$ in this way it is more interesting for truckers to move the conflict from the s_4 state to the s_3 state since they will not be punished and with that, the state s_4 is not GMR stable for truckers.

6.2.2 Government

$R_G^+(s_1) = \{s_3\} \longrightarrow R_C(s_3) = \{s_4\}$, being $s_4 \succ s_1$, then it will be interesting to move the conflict from state s_1 to state s_3 since they will not be punished and, with this, the state s_1 is not GMR stable for the Government.

$R_G^+(s_2) = \{s_4\} \longrightarrow R_C(s_4) = \{s_3\}$, being $s_3 \succ s_2$ for the Government, it would be interesting to move the state conflict to the s_4 state, since they would not be punished and, with this, the state s_2 is not GMR stable for the Government.

We can observe with the above results that the s_1 states is GMR stable for the Truckers while for the Government it would not have stable GMR states.

6.3 SEQUENTIAL STABILITY (SEQ)

Sequential stability aims to model the behavior of a focal decision maker who analyzes his possible movements based on the other decision maker, seeking to know in what situations the opponent will seek improvements of his own that may harm him. [FRASER e HIPEL, 1979] It is worth mentioning that the stable Nash state (s_3) is in the SEQ.

6.3.1 Truck drivers

$R_C^+(s_1) = \{s_2\} \longrightarrow R_G^+(s_2) = \{s_4\}$, being $s_1 \succ s_4$, so the Government can take the state conflict s_2 to the s_4 state, being $R_G^+(s_2) = \{s_4\}$, so it would be better to continue in the s_1 state and with this it is SEQ stable.

$R_C^+(s_4) = \{s_3\} \longrightarrow R_G^+(s_3) = \emptyset$, the Truckers taking the conflict from the state s_4 to the state s_3, the Government is not motivated to move the conflict because it would be in the most preferable, so the state s_4 is not stable SEQ since it has no punishment on the part of the Government from the improvement to the state s_3.

6.3.2 Government

$R_G^+(s_1) = \{s_3\} \longrightarrow R_C^+(s_3) = \emptyset$, the Government taking the conflict from state s_1 to the state s_3, the Truckers did not need to move the conflict because it would be in the most preferable, so it would be better to proceed to the state s_3 e with this the state s_1 is not stable SEQ.

$R_G^+(s_2) = \{s_4\} \longrightarrow R_C^+(s_4) = \{s_3\}$, and $s_3 \succ s_2$ soon the Government could move the conflict from the state s_2 to the state s_4, so truckers can take the conflict from the state s_4 to the state s_3, being the s_3 state preferable to the government with respect to the state s_2, so the state s_2 is not stable SEQ since it has no punishment on the part of the Government from the improvement to the state s_4.

We can observe with the above results that the s_1 states is SEQ stable for the Truckers while for the Government there would be no stable SEQ states.

6.4 SMR

The symmetrical metarrational stability aims to analyze three distinct plays: the move of the focal decision maker, then the play that your opponent will make and finally the answer that will have the decision-making on the play made by your opponent [Howard, 1971]. It is worth mentioning that the stable Nash state (s_3) is in the SMR.

6.4.1 Truck Drivers

$R_C^+(s_1) = \{s_2\} \longrightarrow R_G(s_2) = \{s_4\}$ and $s_1 \succ_C s_4 \longrightarrow R_C(s_4) = \{s_3\}$ and $s_1 \succ_C s_3$, state s_1 is stable SMR.

$R_C^+(s_4) = \{s_3\} \longrightarrow R_G(s_3) = \{s_1\}$ and $s_1 \succ_C s_4 \longrightarrow R_C(s_1) = \{s_2\}$, state s_4 is not stable SMR.

6.4.2 Government

$R_G^+(s_1) = \{s_3\} \longrightarrow R_C(s_3) = \{s_4\}$ and $s_4 \succ_G s_1 \longrightarrow R_G(s_4) = \{s_2\}$ and $s_2 \succ_G s_1$, then state s_1 is not stable SMR.

$R_G^+(s_2) = \{s_4\} \longrightarrow R_C(s_4) = \{s_3\}$ and $s_3 \succ_G s_2 \longrightarrow R_G(s_3) = \{s_1\}$ and $s_2 \succ_G s_1$, then the s_2 state is stable SMR.

We can observe with the above results that the s_1 state is stable SMR for the Truckers while for the Government the state s_2 is stable SMR.

6.5 SSEQ

Symmetric sequential stability occurs when the decider analyzes his next move, taking into account moves that might benefit his opponent, the player will also discard moves that his opponent will not benefit from, in addition to predicting counter reactions that he will have. (RÊGO & VIEIRA, 2016). It is worth mentioning that the stable Nash state (s_3) is in the SEQ.

6.5.1 Truck Drivers

$R_C^+(s_1) = \{s_2\} \longrightarrow R_G^+(s_2) = \{s_4\}$ and $s_1 \succ_C s_4 \longrightarrow R_C^+(s_4) = \{s_3\}$ and $s_1 \succ_C s_3$, then the s_1 state is Stable SSEQ.

$R_C^+(s_4) = \{s_3\} \longrightarrow R_G^+(s_3) = \emptyset$, being $s_3 \succ_C s_4 \longrightarrow R_C^+(s_3) = \emptyset$, so the s_4 state is not stable SSEQ.

6.5.2 Government

$R_G^+(s_1) = \{s_3\} \longrightarrow R_C^+(s_3) = \emptyset$, being $s_3 \succ_G s_1 \longrightarrow R_G^+(s_3) = \emptyset$, thus the s_1 state is not stable SSEQ.

$R_G^+(s_2) = \{s_4\} \longrightarrow R_C^+(s_4) = \{s_3\}$, being $s_3 \succ_G s_2 \longrightarrow R_G^+(s_3) = \emptyset$, and $s_3 \succ_G s_2$, so state s_2 is not stable SSEQ.

We can observe with the above results that the s_1 states is stable SSEQ for the Truckers while for the Government has no stable SSEQ states.

7 FINAL CONSIDERATIONS AND DIRECTIONS FOR FUTURE WORK

It bases the use of the GMCR in its application between the impasse of the Brazilian federal government and the truck drivers in a systematic way in order to present satisfactory and unsatisfactory results in both decision makers, showing stability and the best possibility of resolution amid the context.

The modeling of the conflict and the possibilities of resolution through the GMCR and the mentioned stabilities are demarcated in the study. By sequence, he estimates that he can proceed with the application of computational manipulation with the presented results.

Using the mathematical modeling method, it was possible to coherently define the 4 main states of the conflict portrayed in table 1, which served to assist in the development of different scenarios, thus, using the graphs, we defined the preferences of each decision maker. Based on what we have seen, it is possible to define stability analyses, using: Nash

stability, GMR, SEQ, SSEQ and SMR.

Finally, we would like to make a direction for future work that would be the use of the solution presented in Silva (2019) and Rego et al. (2021) for the preference manipulation problem (PMP) of bilateral conflicts in order to obtain a cost to reach a specific state such as equilibrium state of the conflict [MIGUEL E GOULART, 2021].

REFERENCES

FRASER, N. M.; HIPEL, K. W. Solving Complex Conflicts. IEEE Transactions on Systems, Man, and Cybernetics, v. 9, n. 12, p. 805–816, 1979.

HOWARD, N. Paradoxes of Rationality Theory of Metagames and Political Behavior. [s.l.] The hit press Classics, 1971. v. 1

JASPER FERNANDO. Preço do diesel sobe 5% após volta de impostos e supera patamar da greve dos caminhoneiros. São Paulo, 2021. Disponível em: https://www.udop.com.br/noticia/2021/05/10/preco-do-diesel-sobe-5-apos-volta-de-impostos-e-supera-patamar-da-greve-dos-caminhoneiros.html. Data de Acesso: 06/03/2022

KILGOUR, D. M.; HIPEL, K. W.; FANG, L. The graph model for conflicts. Automatica, v. 23, n. 1, p. 41–55, 1 jan. 1987.

MAZUI, G. Governo e caminhoneiros anunciam proposta de acordo para suspender paralisação por 15 dias. Brasília, 2018. Disponível em: https://g1.globo.com/politica/noticia/governo-faz-proposta-para-suspensao-da-paralisacao-dos-caminhoneiros.ghtml. Data de Acesso: 02/10/2021

MIGUEL, P. L. DE S.; GOULART, D. F. O que a greve dos caminhoneiros nos ensina sobre a logística brasileira? .Rio de Janeiro, 2021. Disponível em: https://portal.fgv.br/artigos/greve-caminhoneiros-ensina-sobre-logistica-brasileira/. Acesso em: 06/03/2022

NASH, J. F. Equilibrium points in n -person games. Proceedings of the National Academy of Sciences, v. 36, n. 1, p. 48–49, 25 jan. 1950.

NASH, J. Non-Cooperative Games. The Annals of Mathematics, v. 54, n. 2, p. 286, set. 1951.

RÊGO, L. C.; VIEIRA, G. I. A. Symmetric Sequential Stability in the Graph Model for Conflict Resolution with Multiple Decision Makers. Group Decision and Negotiation, v. 26, n. 4, p. 775–792, 28 jul. 2017.

SATRIANO, N. Petrobras anuncia redução de 10% no diesel; medida deve valer por 15 dias. Rio de Janeiro, 2018. Disponível em: https://g1.globo.com/economia/noticia/petrobras-anuncia-reducao-de-10-no-diesel.ghtml. Acesso em: 06/03/2022

SILVA, H. V. Manipulação ótima de preferências no modelo de grafo para resolução de conflitos. Dissertação (Mestrado Acadêmico em Modelagem e Métodos Quantitativos) —Fortaleza: Universidade Federal do Ceará, 2019.