



Reviewing the strategies for climate change and sustainability after the US defiance of the Paris Agreement: an AHP–GMCR-based conflict resolution approach

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Abstract

In the landmark Paris Agreement, the global economies agreed to put forward their best efforts in mitigation and adaptation of climate change. The member countries set their international and national targets to limit global temperature rise within 2 °C. The major and developed economics play a productive role in achieving the goals set in the Paris Agreement and failing would make it hard for the global community to limit the global temperature within the targeted range. The announcement of the USA to back out of the Paris Agreement has caused uncertainty in the global climate governance (GCG) regime. The present study overviews how the US defiance is likely to affect emission space, carbon prices, and macroeconomic conditions of the economies. It also focuses on the objective to analyze multiple strategic scenarios regarding GCG considering the role of three major contributors to GHG emissions—the USA, the EU, and China. An integrated conflict resolution strategy has been proposed by combining the analytical hierarchy process and attitude-based graph model for conflict resolution. The possible post-withdrawal scenarios based on possible alternatives for the GCG regime has been examined. This study incorporates influence power-based and attitude-based approaches to generate preference rankings of the alternative GCG strategies. The influence power-based and attitude-based preferences are used in general stability and attitude-based stability analyses to explore equilibrium GCG strategies. The analyses reveal that influence power and attitudes of the decision-makers (DMs) influence the preferences of DMs. This influence on preferences has implications on the outcomes of the GCG scenarios. The results of the influence power-based and attitude-based analyses imply that the collective GCG strategies are indispensable to protect the shared natural climate for environmental sustainability and development.

Keywords Paris Agreement · Climate change · Environmental decision-making · Climate governance · Influence-power · Preference · Attitude-based analysis

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1 Introduction

In the wake of the Paris Agreement, the implementation of policies of mitigation and adaptation has been in the limelight during the last decade. The carbon footprints of human activity, especially in the areas of energy production and consumption (Ahmad et al. 2018; Ahmad and Du 2017; Ali et al. 2019a), allude to the serious consequences of climate change. This puts heavy responsibility to follow the policies of mitigation and adaptation to limit emissions and climate change. The inhabitants of the planet are facing an unprecedented and severe threats of climate change in human history resulting in rising global temperatures, sea-level rise, and unexpected and irregular changes in the climatic system (Ahmad et al. 2018; Ahmad and Du 2017; Gao et al. 2017; IPCC 2014; Nieto et al. 2018; Ostberg et al. 2018). The IPCC (2014) warns that it would be “more improbable than probable” to maintain the rise in global temperature to below 2 °C as compared to pre-industrial times if it is not managed to reduce the emission levels between 25 and 72 percent with respect to 2010 by 2050. Recognizing these concerns, 195 countries, at the 21st Conference of Parties (COP21) of the United Nations Framework Convention on Climate Change (UNFCCC), reached a consensus and agreed to sign the PCA (UNFCCC 2015a, b). The agreement is aimed to “hold the increase in the global average temperature to well below 2 °C above pre-industrial levels” and “pursue the efforts” to curtail global temperature rise to 1.5 °C above the pre-industrial levels (UNFCCC 2015b). The collective global efforts could limit the adverse impact of climate change (Gao et al. 2017; Nieto et al. 2018; Spash 2016a; Tobin et al. 2018; UNFCCC 2015b).

The PCA has been considered as a milestone in human history regarding the policy of efforts to address climate change induced by human activity (Spash 2016b). It is different from previous climate conventions or agreements. Each member country, in PCA, has established its voluntary objectives through the Intended Nationally Determined Contributions (INDCs) (Nieto et al. 2018; Spash 2016a; UNFCCC 2015b). The climate agreement focuses on INDCs rather than a set of planned and coordinated reductions in GHGs by targeting fossil fuel combustion and those responsible for GHG emissions. Though the agreement recognizes the human-induced climate change, the provisions made for adaptation do not force responsibility on the agreed parties which explicitly excludes the liability and compensation mechanism (Spash 2016b). The projections show that even if all the pledges made by the member states are fully contributed and mitigation and adaptation are implemented, the world would end up with a 2.7 °C rise in global temperature above that of pre-industrial levels (UNFCCC 2016). Still, this rise in global temperature is very high and would further worsen the climatic conditions. But it is more likely that the voluntary pledge could not be implemented by the member states. The voluntary nature of the parties’ commitment and the nonexistence of any monitoring, control, and penalizing system would have serious insinuations regarding the achievements of goals set in the PCA (Nieto et al. 2018). The agreement itself proclaims to promote sustainable development. However, sustainable development needs economic growth, industrialization, technological advancement, and efficient energy use (Spash 2016b). So, there is an inherent tendency of providing the parties choice(s) to ignore the environmental aspects while setting the trajectories of their growth on the way to higher growth. The conflicting objectives of growth and environmental sustainability put the national economies at crossroads on the way to sustainable development.

The structure of the PCA is based on the bricks of INDCs that makes its implementation uncertain and legacy fragile to any policy switch consequent upon the change of the government in a member state. Moreover, political orientation and ideology significantly influence the attitudes and responses to climate change. To be more specific, the political leadership with the right-of-center ideology has less concerned and more skeptical views about climate change (Whitmarsh and Corner 2017). The leadership tends to affect public opinions regarding the issues such as climate change (Kousser and Tranter 2018). Any change in the preference of the leadership in a country and any domestic policy shift could compromise the future of the climate agreement. Despite the pledges to adaptation and mitigation by the signatories of the PCA, developed economies (in general) and developing economies (in specific) are at the crossroads. Sustainable stellar growth demands more energy use and higher consumption levels given the state of technology available at hand. It creates a conflict of interest within the countries whether to adopt renewable energy sources and environmentally friendly patterns of consumption by sacrificing, possibly, higher growth or set their trajectories based on traditional energy sources and push the world on the verge of environmental catastrophe. In the post-PCA scenario, the change in the government in the USA changed the paradigm of GCG. The US administration announced to back out of the PCA (Barclay 2017; Boffey et al. 2017; Carrington 2017; Milman et al. 2017; Zhang et al. 2017a, b) motivated by the host of reasons discussed in (Zhang et al. 2017a, b). The US president termed global warming just a hoax. The climate agreement has been considered a restriction on the USA while empowering the other countries(s). President Trump has undone the climate policies of the former US administration in Washington. Intending to re-stimulate the US traditional fossil fuel energy industry, the new administration annulled the Clean Power Plan (CPP) and issued orders to promote energy independence and economic growth. In addition to this, there was a drastic cut in the federal budget to be spent on climate change policies and research (Zhang et al. 2017a, b).

The US exit would not only affect emission space, mitigation cost, and growth trajectories for the USA itself but also for other economies (Dai et al. 2017). This situation may have a heavy toll on the efforts of climate change as it could lead to serious conflicts between the member economies of PCA, especially the leading economies such as the EU, China, and the USA. Dai et al. (2017) has projected the changes in the emission space, mitigation cost, and growth of the largest polluting economies. The USA under Obama's administration along with the EU and China played a leading role in reaching a global consensus for climate governance regime. It makes the US's compliance with the agreement critical for its effective implementation and achievement of targets set in the agreement (Parker et al. 2017; Zhang et al. 2017a, b). The US's administration decision to exit PCA has been disapproved by the world. Though the EU member economies along with China, India, Japan, and other major economies have shown their commitments to the agreement yet still there would be a leadership vacuum after the US back-out. Each leading economy has its options and strategies to align its economic policies vis-à-vis climate change policies. Moreover, the US policy shift for climate change has created uncertainty regarding the future of the climate agreement. This would also affect the economic, trade, and strategic relationships of the major economies such as China, the EU, and the USA as the US decision would affect the emission space, mitigation cost, and growth of other member states in the agreement. This may create conflict(s) among the member states regarding the implementation of agreed terms and targets set in the agreement. Moreover, there would be a leadership vacuum in global climate governance regimes for the smooth implementation and monitoring for the mitigation and adaptation in the efforts to climate

change. There is a need for a suitable and efficient conflict resolution strategy to resolve the global environmental governance dispute.

This study is an effort to represent a negotiation strategy to reach a feasible outcome that could be a win–win for all the stakeholders. The GMCR approach is a suitable technique to analyze strategic conflict(s) (Ali et al. 2018, 2019a, b; Fang et al. 1993; Xu et al. 2018a, b). The power of the DM(s) influences the conflict and course of action (Yu et al. 2015). The decision-makers (DMs)' evaluation or perception of power about themselves and other DM(s) in a conflict affects the outcome(s) of the conflict. Moreover, a DM's standpoint about its influencing power in conflict and its perception about the influencing power of other DM(s) could change the preference of the DM(s). Furthermore, a DM's perspective about its own preferences on its options and other DM(s)' preferences about their own options could also play a critical role in the overall preference rankings of the different states or strategies in a certain conflict. This, in turn, may significantly affect the nature and outcomes of conflict. The perception of the influencing powers of the DMs and their choices among the options in a certain situation could explain the behavioral patterns of these DMs. The behavioral patterns of the DMs based on their attitudes can play a critical role in responses, moves, countermoves of the DMs. The attitude of the DMs and its effect on the DMs' behaviors are also important to understand the nature, evolution, and finally to obtain an equilibrium negotiation strategy to resolve a conflict for a win–win situation for all (Ali et al. 2019a, b; Inohara et al. 2007; Xu et al. 2017a, b, 2018a, b; Xu et al. 2018a, b).

The present study contributes in two ways. *First*, it overviews the scenarios regarding the impact of the US back-out on the implementation and future of the PCA. It overviews how the US defiance of the PCA would affect emission space, mitigation cost, and growth trajectories of the largest polluting economies, especially, the USA, the EU, and China—the top 3 contributors to global GHG emission. *Second*, the study considers the multiple possible scenarios regarding climate governance regime. For this, this study takes possible policy responses of major contributors to GHG emissions. It is important to examine how these major members of the PCA could play their roles in climate governance regime. In doing so, the present analysis puts the post-exit scenario into perspective and proposes a suitable negotiation strategy to resolve the climate agreement conflict. This study focuses on the analysis of the decision-making behavior of the DMs in the situation of conflict that emerged in global environmental governance (GEG). Two different methods of preference ranking are employed to understand the behavioral patterns of DMs and their impacts on overall preference ranking and outcomes of the climate agreement conflict. *First*, the attitude-based-on options approach (Xu et al. 2017a, b) in the GMCR (Fang et al. 1993; Kilgour and Hipel 2005; Xu et al. 2018a, b) is employed to examine the insinuations of the attitudinal behaviors of the DMs in the perspective of a GEG issue. The influence power- and attitude-based study analyzes how different attitudes of the major players in global environmental governance—the USA, the EU, and China—change the course(s) of action(s) and what possible solution strategies could be traced out to move forward in the efforts to combat climate change. *Second*, the influence powers of the DMs with their influencing powers and their opponents' influencing power in climate agreement issues with each DMs standpoint are incorporated in the attitude-based GMCR to assess the behavioral aspects of the DMs in their moves and countermoves. Moreover, the pairwise comparisons of each DM's option and other DMs' options with the standpoint of each DM are also incorporated to obtain hybrid preferences of the DMs based on their influencing power and their pairwise comparison matrices on options. Ke et al. (2012) introduced the adapted AHP approach to take into consideration the influence power to generate

preferences and incorporated it in the GMCR. The present study uses this approach for the preference ranking and incorporates the preference based on influence power in the GMCR while considering the attitudes of the DMs. This study combines the influence power and attitudes to trace out equilibrium strategy for the resolution of the climate agreement dispute in global environmental governance. These influence power-based hybrid preferences are used for attitudinal stability analysis in the GMCR to trace out the equilibrium solutions. The integrated GMCR approach carries out stability analyses while considering the different attitudes of DMs. This attitudinal analysis based on power-based preferences would help to understand how the DMs' standpoint about their own power and their opponents' power to influence the situation in the climate agreement conflict. It also represents how the power-based preferences and changes in DMs' attitude change the possible equilibrium outcomes of the conflict.

2 The Paris climate agreement conflict

2.1 US declaration of exit from PCA

The US president, in June 2017, announced the pullout from the PCA and also pronounced the renegotiation to re-enter the accord on new terms that were fair to the USA (Boffey et al. 2017; Milman et al. 2017; Reuters 2017; Visser 2017). The US domestic policies and President Trump's personal preferences drive the US back-out rather than any burden on the largest economy in the world by the climate agreement. Even though increasingly profitable and growing popular pressure forced the politicians to take action to combat climate changes (Newport 2017), However, USA president administration is on the roll-back of Obama's climate policies and regulations. The president proclaimed that the USA could try to re-enter the deal in the landmark PCA under more favorable terms. However, the lengthy exit process, outlined in the deal, would be followed. According to Article 28 of the PCA (UNFCCC 2015b), a signatory nation of the agreement can submit a withdrawal three years after the agreement entered force (*i.e.* November 4, 2016). The USA can pull out of the PCA but not earlier than November 3, 2020 (Boffey et al. 2017). It means the USA would remain in the agreement (though formally) for another three-and-a-half years (Hunt et al. 2017). The US president argued that the PCA disadvantaged the USA for the benefit of the other countries. It would cause workers and taxpayers to absorb the cost and suffer joblessness and factory closures. Moreover, the USA would also cease implementation of the nationally determined contribution and GCF which is also believed to be a great cost to the US economy (Milman et al. 2017). The national premiers and governments all over the globe reassured their determination and commitments for global environmental governance. The leaders from China to India to Russia to the EU have reasserted their commitment to encounter the unprecedented challenge faced by modern civilization (Carrington 2017).

The EU deeply regretted Trump's unilateral back-out decision from climate agreement (Reuters 2017). The EU rejected the USA offer to renegotiate the PCA. The former pledged to work directly with the US states and leading corporations bypassing Washington. Germany, one of the leading members of the EU out-rightly refused to engage in negotiation with the USA. The president of the European Council (EC) criticized

president Trump's decision and asserted that the efforts to fight against the menace of climate change would continue with or without USA. China and Europe showed solidarity with the generations to come (Boffey et al. 2017). China, the world's biggest polluter, most remarkably, has transitioned from "climate laggard to climate leader" in recent years and furthermore, it is becoming a dominant renewable energy technology supplier in the world (Carrington 2017). The UK also considered that PCA was a suitable global framework for protecting the environment for the future while keeping energy affordable and securing the citizens and the business (Boffey et al. 2017). France and Italy has also criticized the US move. Furthermore, it was also argued that the results of elections in a signatory country could not affect the fight against climate change. The USA is supposed to fulfill its commitments made in the international agreement (Boffey et al. 2017; Keating 2018; Milman et al. 2017). The global effort to fight climate change would not be derailed by the US withdrawal. Moreover, it is also argued that the states, cities, investors, and corporations have been moving toward the consensus on efforts to tackle climate change. In addition to this, the cost of renewable has been dropping that guarantees the continuation of the transition to alternative sources of energy (Milman et al. 2017). President Trump's decision has also been disapproved by blue-chip companies including Apple, Ford, Microsoft, and Facebook. Moreover, several US states have also vowed to ignore Washington's decision on PCA (Boffey et al. 2017). Despite the commitments and determination of the rest of the world, the US's decision would have serious implications on the efforts to mitigate and adapt.

2.2 Consequences of the US exit from the Paris Agreement

The US withdrawal from the PCA would have serious insinuations on prospects of acquiescence with the agreement. The universality of the international climate agreement is the backbone of the global climate regime and it brings forth the legitimacy enhancing the effectiveness of climate governance (Zhang et al. 2017a, b). Meeting the targets would be possible with the reduction in the fossil fuel consumption to below a quarter of the primary energy supply by 2100 if negative emission technologies, on a global scale, remain unfeasible technologically or economically (Walsh et al. 2017; Zhang et al. 2017a, b). The US withdrawal could add to 0.3 °C to the global temperature by the end of the twenty-first century (Boffey et al. 2017).

Multiple pathways to the zero emission are needed to avoid the severe, prevalent, and irreversible impacts of global warming. The USA agreed to reduce carbon emissions between 26–28 percent below the 2005 level by 2025. But, in March 2017, the US president issued guidance in an energy executive order aiming to roll back rules to cut carbon emissions from electricity production.¹ Even if the US carbon emissions remain constant, if not compensated by the rest of the world, still there would be enough to hit the most vulnerable nations by global warming and rising oceans (Carrington 2017). The flattened emissions by the US economy would cause an additional 0.3 °C increase by 2100, which would cause to push the global temperature to rise well beyond 2 °C above the pre-industrial era. That, in turn, would source extreme heatwaves, a rise in sea level, loss of ecosystems, and the displacement of millions of people (Milman et al. 2017; Zhang et al. 2017a, b). The US back-out would be a bad precedent in the GCG. It would also cease all

¹ Presidential Executive Order on Promoting Energy Independence and Economic Growth. <https://www.whitehouse.gov/presidential-actions/presidential-executive-order-promoting-energy-independence-economic-growth/>.

implementation of the non-binding PCA. It includes US contributions to the UN Green Climate Fund (GCF) to support poorer and less developed countries in adapting to climate change and expanding clean energy. France, Germany, and Italy regretted the US decision and asserted no renegotiation on PCA (Hunt et al. 2017). Any failure in achieving the NDCs by the USA would make it a free-rider on the mitigation efforts made by other countries. Though, most of the countries are reaffirming their commitments to the climate agreement, there may be changes in climate politics in these countries too. About 350–450 Gt of CO₂ would be emitted if the other countries, following the USA, delay mitigation for 8 years or cut renewable energy research. This would make 2 °C targets of the PCA almost unattainable (Zhang et al. 2017a, b). Apart from this, the US's decision would not only affect its own emission space, carbon prices, and macroeconomic conditions in the economy but it would also affect the same in the rest of the world (Dai et al. 2017; Zhang et al. 2017a, b).

2.2.1 Changes in the emission space

The USA would gain more emission space and lower mitigation costs with its back-out from the agreement, but it would squeeze other countries' emission space and raise their mitigation costs. It would make more difficult and expensive to attain the 2 °C targets of the PCA (Dai et al. 2017; Zhang et al. 2017a, b). Dai et al. (2017), in their global computable general equilibrium model, predict that under the NDCs target, if the USA decreases its emissions by 20 percent, 13 percent, and zero percent below the 2005 levels by 2025, it will decrease the emission space in the EU by 1.1 percent, 1.8 percent, and 3.3 percent, in 2030. If the USA, under the 2 °C target, reduces its emissions by 20 percent, 13 percent, and 0 percent below the 2005 levels by 2025, the emission space in the EU would decrease by 1.7 percent, 2.9 percent, and 5.5 percent, respectively, in 2030. Predictions in Dai et al. (2017) reveal that the emission space would also decrease in China by 0.8 percent, 1.6 percent, and 3.2 percent by 2030 if the USA, under the NDCs target, only reduces its emission by 20 percent, 13 percent, and zero percent below that of 2005 by the year 2025, respectively. Under the 2 °C target, the emission space in China would decrease by 1.7 percent, 2.8 percent, and 5 percent.

2.2.2 Changes in carbon price

Moreover, there would be an increase in the carbon price. In 2030, if the USA, under the NDCs target, only reduces its CO₂ emissions by 20 percent, 13 percent, and 0 percent below the 2005 levels by 2025, the carbon price would rise 3.6–14.9 US\$ t⁻¹ in the EU. However, under the 2 °C target, the carbon price would increase in the EU by 9.7–35.4 US\$ t⁻¹. In China, the carbon price would rise by 1.1–4.6 US\$ t⁻¹ under the NDCs target. Under the 2 °C target, the carbon price would rise by 4.4–14.6 US\$ t⁻¹ in China (Dai et al. 2017).

2.2.3 Macroeconomic impacts of the US back-out

There would be additional GDP losses associated with the emissions. The predictions in Dai et al. (2017), reveal that with the reductions in emissions by 20 percent, 13 percent and zero percent by the USA under the NDCs target below the levels in 2005 by 2025, there

would be additional GDP loss would be US\$ 3.14–13.22 billion (i.e., per capita GDP loss of US\$ 6.9–29.3) in the EU. Furthermore, under the 2 °C target, in the EU, the additional GDP loss would be US\$ 9.35–32.14 billion (i.e., loss of US\$ 20.7–71.1 per capita GDP). Under the NDCs target, the predicted additional GDP loss in China in 2030 is US\$ 4.75–19.77 billion (i.e., per capita GDP loss of US\$ 3.5–14.8). However, under 2 °C targets, it would be US\$ 21.98–71.1 billion which is a per capita GDP loss of US\$ 16.4–53.1.

2.2.4 Impacts of the US back-out on developing countries

The climate agreement ensures that the developed economies would contribute US\$ 100 billion to the GCF by 2010 to help the poor and developing economies in setting their climate policy for mitigation and adaptation. It would be difficult for these economies to mitigate and adapt to climate change if the USA backs out from the PCA and cuts the climate aid to finance mitigation and adaptation. The USA has been a top contributor to the Global Environmental Facility (GEF). The USA, in 2014, pledged US\$ 3 billion to the GEF and has appropriated about 40 percent in US\$ 2.42 billion funds so far (Zhang et al. 2017a, b). The GCF could help the developing world to fight against the risks of global warming. The GCF is supporting more than 43 projects in the Caribbean, Latin America, Eastern Europe, and the Asian Pacific region. The withholding of promised contributions to the fund by the USA would adversely affect the climate changes efforts in the poor and least developed economies (Barclay 2017). Climate change is an acute threat to the inhabitants of these countries. This threat could not be contained without rapid and inclusive development while taking into consideration climate change, adaptation, and reductions in emissions. Climate change is likely to affect the poor. If not handled properly, it could push more than 100 million additional people worldwide back into the abyss of poverty by 2030.²

3 The conflict analysis methodology

This section describes the methodology used for the analysis of climate agreement conflict in global environmental governance. First, it introduces the GMCR (Fang et al. 1993; Xu et al. 2018a, b). Second, it explains the preference ranking methods used to generate ranking of the states or alternative strategies for further analysis. Two different methods are used to generate the preference of the states. First, preferences are generated based on options (Ali et al. 2019b; Xu et al. 2017a, b). Second, the integrated approach suggested in (Ke et al. 2012) is used to incorporate the influence power of each DM with each DM's standpoint. These preferences based on influence power are used for the first time in the framework of the GMCR for the attitudinal analysis. Finally, the relational stability definitions used in the analysis are discussed briefly.

² The World Bank reports "rapid, climate-informed development needed to keep climate change pushing more than 100 million people into poverty by 2030. <http://www.worldbank.org/en/news/feature/2015/11/08/rapid-climate-informed-development-needed-to-keep-climate-change-from-pushing-more-than-100-million-people-into-poverty-by-2030>.

3.1 The graph model for conflict resolution

The GMCR is a simple but flexible approach designed to analyze conflicts surfacing in a wide range of real-life areas ranging from military conflicts, peace-keeping, natural resource conflicts (Yu et al. 2015), brownfield remediation, and environmental management (Ali et al. 2017; Hipel and Walker 2011; Ke et al. 2012; Kilgour and Hipel 2005), energy-environment conflict (Ali et al. 2019a), regional infrastructure development conflicts under the Belt and Road Initiative (BRI) of China (Ahmed et al. 2018), strategic conflict (Ali et al. 2018; Xu et al. 2017a, b), urban planning and heritage protection in historical cities (Ali et al. 2020, 2019b), and transboundary dispute resolution for the protection of glacial ecosystem (Ali et al. 2019b). The GMCR provides an easy-to-use and flexible methodology for modeling and analysis of conflict. It provides the analysts with the liberty to put a complex strategic conflict into perspectives and attain a deeper insight into the current conflict and envisions potential resolutions (Fang et al. 1993; Hipel et al. 2019; Xu et al. 2018a, b).

The GMCR approach (Fang et al. 1993) to conflict analysis comprises four basic components: (1) a set of DMs ($N = \{1, 2, 3, \dots, n\}$); (2) a set of states or nodes ($S = \{s_1, s_2, \dots, s_k\}$); and (3) a collection of finite directed graphs (i.e., $\{D_i = (S, A_i)_{i \in N}\}$) (see Fig. 1). Here, D_i is the directed graph tracking out unilateral moves of DM i , each arc of which stands for a move that DM i could make in one step from a specific state to other state(s). The set of these states is known as a reachable list of that DM; and (4) each DM's preference over S . For $i \in N$ and $s_1, s_2 \in S$, the preference $s_1 >_i s_2$ implies that the DM i prefers s_1 on s_2 and $s_1 \sim_i s_2$ implies that the DM i is indifferent between the two states. Each DM has its own preference on states considering the actions or states of other DMs during the negotiation process in the state of conflict (Xu et al. 2018a, b).

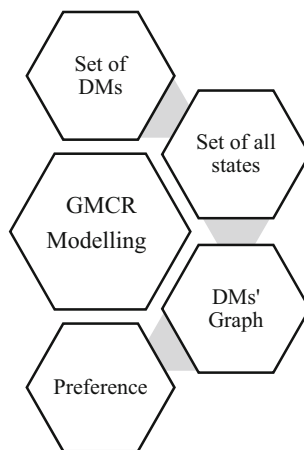


Fig. 1 Components of graph model for conflict resolution

3.2 Preference ranking

The generation of preference of each DM over S is an indispensable step in the GMCR approach. The feasible states are ranked from most preferred to least preferred for each DM (Xu et al. 2018a, b). The present analysis utilizes two methods of option prioritization.

3.2.1 Preference ranking under the attitude based-on options

The attitude of the DMs is important in the preference ranking of the feasible states (Inohara et al. 2007; Xu et al. 2017a, b). Inohara et al. (2007) generated the preference ranking directly from the states considering the attitude of the DMs. But it makes the preference generation cumbersome if the number of states is larger. In a recent study, Xu et al. (2017a, b) suggest state prioritization based-on options. It is a flexible and easy approach to prioritize the states while considering the attitude of the DMs. This analysis considers three of the attitudes of DMs; positive (+), negative (-), and neutral (0). This attitude of the DMs can be incorporated in GMCR according to the options statement of each DM. If DM i has a positive attitude for a DM j , it has a devoting preference for DM j (Inohara et al. 2007) and its option statement would be similar to that of the DM j (P. Xu et al. 2017a, b). If a DM i has a negative attitude for the opponent DM j , it would have an aggressive preference for DM j (Inohara et al. 2007) and it would have its option statement opposite to that of DM j and it would be disadvantageous to DM j (Xu et al. 2017a, b). However, the DM i would be indifferent about DM j 's option statement if it has a neutral attitude for DM j . Based on its attitude, the DM j would have its attitude preference and total attitude preference based on his option statement under a specific attitude (Xu et al. 2017a, b). For the mathematical formulation of attitude preference, total attitude, set of less or equality preferred states at total attitude, reachable list, and set of unilateral improvement based on attitude (Xu et al. 2017a, b).

3.2.2 Preference ranking based on influence power

The state prioritization approaches discussed in the last subsection whether based on ranking directly from states or based-on options are qualitative. The present study also utilizes the quantitative cum qualitative adapted in Ke et al. (2012) for state prioritization. The adapted approach generates the ranking of the states while taking the influence powers of the DMs into account. The adopted approach is based on the Analytical Hierarchy Process (AHP) suggested in Saaty (1980, 1995). The AHP streamlines a complex decision problem by breaking it down into hierarchies such as focus, criteria, sub-criteria, and alternatives. Following the AHP procedure in Ke et al. (2012), the preference ranking of the states have been obtained as shown in Fig. 2.

In the next step, pairwise comparison matrices are developed for each focus, criteria, and sub-criteria in the present case DMs, their influence power, and the options, respectively. These matrices comprise the relative priorities of elements. At each level, these present different objects: DMs, their influence power, the options. For example, for a specific criterion or sub-criterion C with m elements below it Y_1, Y_2, \dots, Y_m a comparison matrix can be attained. In each matrix, y_{ij} indicates the pairwise comparison result of the elements Y_i and Y_j with respect to element C . In the matrix, it is obvious to have $y_{ii} = y_{jj} = \dots = y_{mm}$ and $y_{ij} = 1/y_{ji}$, where $i, j = 1, 2, \dots, m$. Following the AHP method in

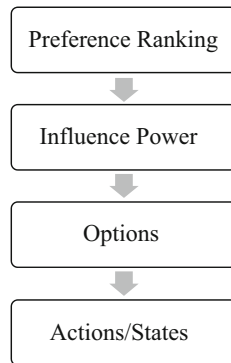


Fig. 2 Adapted AHP approach for state prioritization with influence power (Ke et al. 2012)

(Saaty 1980, 1995, 2008), a scale of ‘1’ to ‘9’ is espoused to conduct nonquantitative pairwise comparisons of two elements.

Following Ke et al. (2012), the preference ranking level contains all DMs included in the present climate agreement conflict model. The objectives are to obtain the preference for all DMs. First, the influence power level takes into consideration the DM’s influence power over the entire situation from the standpoint of each DM. Influence power weight is obtained to explain the power of all DMs based on each DM’s assessment. Second, the priority weights of each DM’s options under its control are estimated. Third, at the action or state level, the overall preference ranking is determined by multiplying option priority weight and action status. Action status is taken binary as “1” or “0”. If an option is chosen by a DM, it is denoted by “1” and “0” otherwise. After obtaining the action weight of each state for each DM, the ranking of states is obtained from the most preferred to the least preferred state. These state preferences based on the influence power of DMs are then put into the MRCRDSS software for stability analysis of each state for all DMs.

3.3 Stability analysis

The analysis of the DM’s moves and countermoves is a major step in the GMCR approach. Presumably, each DM could only move from a state to other state(s) unilaterally having other DMs’ actions fixed. A state is stable for a DM if he has no motivation to move away from a certain state unilaterally. A state is an equilibrium or solution of conflict if it is stable for all DMs under a certain solution concept (Fang et al. 1993; Kilgour and Hipel 2005; Xu et al. 2017a, 2018a, b). Solution concept or a stability definition is a set of rules to estimate whether a DM would move away unilaterally from a state or stay at it. Therefore, a stability definition/concept is a strategic approach of a DM or, more generally, of human behavior in a strategic conflict (Xu et al. 2018a, b). The characteristics of most commonly used stability concepts in the GMCR framework are Nash stability (NASH) (Nash 1950, 1951), general metarationality (GMR) (Howard 1971), symmetric metarationality (SMR) (Howard 1971), and sequential stability (SEQ) (Fraser and Hipel 1984), summarized in Table 1. More detailed mathematical definitions are presented in (Fang et al. 1993). The features of these definitions are summarized in Table 1. The foresight in the first column of the table refers to the maximum number of moves foreseen by a DM

Table 1 Stability concepts explaining the DM's behavior in a conflict [based on Table 1.6 in (Xu et al. 2018a, b)]

| Stability concept | Foresight | Dis-improvements | Strategic risk | Description |
|-------------------|-----------|------------------|----------------------------|---|
| NASH | Low | Never | Focal DM ignores risk | A DM cannot make a unilateral move to a more preferred state(s) |
| GMCRCR | Medium | By opponent(s) | Conservative; avoids risks | The DM i anticipates that the opponent DM would respond to DM i 's improvement and would sanction DM i 's unilateral improvement at any cost |
| SMR | Medium | By opponent(s) | Conservative; avoids risks | The DM i anticipates that the opponent DM would respond to DM i 's improvement and would sanction DM i 's unilateral improvement at any cost |
| SEQ | Medium | Never | Some risk; satisfies | The DM i anticipates that opponent DM would respond to DM i 's improvement and would sanction DM i 's unilateral improvement but only with her improvement(s) |

under a specific stability definition. A DM looks one move ahead under NASH stability. However, in the conservative concepts of stability (GMR, SMR, and SEQ), the DM looks two or three moves ahead. A state that is NASH stable is also GMR, SMR, and SEQ. However, a state stable under any other stability definition must be GMR stable. In addition to this, GMR and SMR describe a conservative behavior of a DM as the DM expects that his opponent would sanction this move if he could do so irrespective of whether this sanction is harmful to the sanctioning DM (Fang et al. 1993; Xu et al. 2018a, b).

Inohara et al. (2007) presented the logical attitude-based stability definitions to incorporate the attitudes of the DMs in the decision-making. The matrix presentation of these logical stability concepts is presented in (Walker et al. 2013). The mathematical representations of attitude-based stability are illustrated in (Walker et al. 2013; Xu et al. 2017a). The matrix representations of attitudes in conflict analysis extended the flexibility to attitudinal calculations, encoding, and development of a Decision Support System (DSS) based on Matrix Representation for Conflict Resolution (MRCR) (Xu et al. 2018a, b). Both stability definitions (general, and attitudinal) are implemented in the MRCRDSS.

4 Modeling the climate change conflict

The conflict analysis approach provides a suitable methodology to model, analyze, and resolve conflict (Walker et al. 2013; Xu et al. 2017a, b). Generally, the fundamental elements of the conflict graph model comprise the DMs, choices or options, feasible states that explicate alternative scenarios or strategies, preferences, state transitions, and a set of directed graphs. Stability analysis, based on calibrated conflict model, reconnoiters the possible moves and counter-moves among the DMs as they long for a position according to their value systems or interests to reach a possible solution from which they have no enticement to move (Fang et al. 1993; Xu et al. 2018a, b). The present study models the climate change conflict, appearing in the wake of the US defiance of the Paris Agreement,

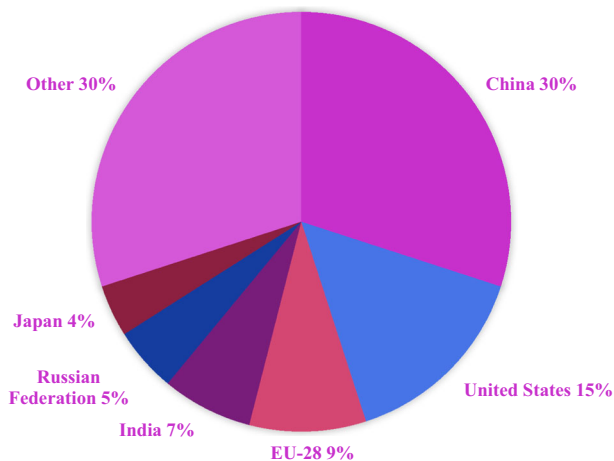


Fig. 3 CO₂ emissions from fossil fuel combustion and other industrial processes (Boden et al. 2017)

to trace out the equilibrium strategy that may be acceptable to all the stakeholders in the climate agreement.

4.1 The decision-makers and options

In the context of the UNFCCC, the institutional development for GCG, in the wake of the Paris Agreement, is multilateral, multilevel, complex, and of influential nature. Despite the intensive participation of subnational entities such as states, provinces, cities, Non-Governmental Organizations (NGOs), enterprises, and local government, the national governments have a major role to play and have central importance in climate governance (Zhang et al. 2017a, b). More importantly, the major contributors to global GHG emission such as the USA, the EU, and China. These economies are the major contributors to carbon emissions globally (Boden et al. 2017) (see Fig. 3).

Withdrawal of the USA (i.e., the second-largest polluter) from the climate agreement may make it a free rider, a consumer rather than a supporter of the GCG. This, in turn, may affect the willingness and commitments of the other member states (*ref.* Zhang et al., 2017a, b), especially the developing economies. The national economies are intertwined and more interdependent than any other time in the economic history of the world. The US's decision to withdrawal would also affect the geopolitical relationship among the major economies. It may have serious implications on international political economics thereby greatly affecting the environmental political balance between the major players in the field of global climate governance such as China, the EU, and the USA (Zhang et al. 2017a, b). In addition to this, the cut in the financial support to the Multiple Environmental Fund (MEF) and refusal from the USA to fulfill the NDC commitments would set a bad example for the other countries. It would be shocking for the global cooperation mechanism developed in the climate agreement (Boffey et al. 2017). Each member country is a stakeholder in PCA to protect the global environment. The leadership of the USA, the EU, and China played a fundamental role in making the PCA. Their leadership and compliance would also be essential in its implementation (Parker et al. 2017; Zhang et al. 2017a, b). However, the overview of the background of the climate agreement conflict unveils the USA, the EU, and China as the major players/DMs in the climate agreement conflict.

4.1.1 Options for USA

The USA has two options. First, it has the option to exit from the PCA (*exit-PCA*). If the USA decides to back out of the PCA, it would take four years to fully execute the exit. According to the agreement, it takes three-year time for a signatory country to back out and after that, it would take a year for notification of final withdrawal from the agreement.³ This option may be easier for the USA because it can return to negotiations if future US administration would want to. In this situation, the USA would be able to keep some presence in the negotiations and reenter the world community on the issues of climate change as it did in the Kyoto Protocol (Beeler 2017). The USA may choose to withdraw from the UNFCCC—the body that created both the Kyoto Protocol and the PCA. This option is quicker as it would take only one year to back away, but this move would be more drastic for the US administration. The decision of the present administration would be harder for future administrations to reverse. This option may not be favorable for the USA. The decisions made by other countries may affect the interests of USA. The US administration would not be able to defend US interests without its presence in the UNFCCC (Beeler 2017). The USA may have a second option (*rev-T*) to remain in the PCA but with revised targets (Beeler 2017). According to the US president, the climate agreement would undermine the US economy, cause unemployment, weaken national sovereignty (Reuters 2017). So, the USA has demanded the renegotiation to come up with favorable conditions in the climate agreement.

4.1.2 Options for EU

The EU has played an indispensable role in the formation of the PCA (Parker et al. 2017). After the announcement of the back-out of the climate agreement, the EU can use the option to renegotiate with the USA (option *Reneg*). President Trump has already said that the US would stay in the agreement if the terms of the deal were renegotiated and changed to be favorable to the USA (Boffey et al. 2017; Keating 2018; Milman et al. 2017). However, the European Council (EC) has described the US withdrawal as a big mistake and proclaimed that the efforts against climate change would continue with or without the second-largest contributor to global emissions (Boffey et al. 2017). The EU can use its option to associate the Paris Agreement with the trade agreement with the USA (option *PCA-TTIP*). France, an important member of the EU and a strong advocate of the PCA, has insisted that Transatlantic Trade and Investment Partnership (TTIP) with the USA could not be revived if the USA backs out climate agreement. The EU's trade chief also backed the stance of “*no Paris Agreement, no trade agreement*” of France's foreign affairs minister (Keating 2018; Stone 2018). Apart from the above two options, the EU also has the option to bypass Washington to engage the state governors and business leaders to implement the unprecedented commitments made in the climate agreement. Many of the US states and corporations have already pledged to live by the terms forged in the PCA (Boffey et al. 2017).

³ Article 28 of the Paris Climate Agreement (UNFCCC 2015b).

4.1.3 Options for China

The climate policy of the new administration in the USA has created uncertainties for the GCG. However, the US's announcement to withdraw from the PCA is both a challenge and an opportunity for China (Bin Zhang et al. 2017a, b). It is an important question whether China can play a promising role in the implementation of the PCA and GCG by enhancing its soft power in the international arena. China considers the PCA a milestone in the history of climate governance. China believes that the efforts to implement the PCA should not be derailed. China would take steps to tackle climate change and would honor its commitments and obligation.⁴ In the current scenario, China would respond to the implementation of the PCA. Zhang et al. (2017a, b) pointed out three options that China might have to tackle the uncertainty in GCG. First, under the G2 partnership, China and the USA jointly laid the groundwork for the PCA in the Paris negotiations. China has the option to engage the USA to move together in the efforts in GCG. But after the US announcement to withdraw from the agreement this partnership seems to reach an end. China may pursue to forge a new G2 with the EU in the efforts in GCG. The China–EU G2 (*new-G2*) could fill the vacuum of the leadership for PCA. The EU, rejecting the US demands for renegotiation, vowed to team up with China in the efforts to attain the target of limiting the global temperature well below 2 °C above the pre-industrial levels (Reuters 2017).

4.2 Feasible states and option statements

After the overview of the Paris Agreement conflict, the authors come up with three main players in the decision-making process of the climate accord. The USA, the EU, China have two, three, and three options, respectively. Mathematically, there would be 256 states in total. Each state represents a strategy. All the states are not feasible. Owing to the mutual exclusivity of most of the states, most of the states are infeasible. For instance, the options 1&2, 1&3, 2&4, 2&5, 3&4, 3&5, 4&5, 6&7, 6&8, and 7&8 are mutually exclusive. The state with all “N” (NNNNNNNN) or all “Y” (YYYYYYYY) is infeasible. States NNNY---, NNNY---, and ----NNN are also infeasible. After deleting the infeasible state, there are 15 feasible states (Table 2). The “1” for an option means the option is chosen by the controlling DM, and “0” otherwise.

4.3 Preference ranking of the states

Preferences ranking of strategies is an important step in the GMCR approach. The stability analysis of each feasible strategy is carried out based on the preferences rankings. Preference ranking determines the movement of the DM(s) across the feasible states considering the moves and countermoves of the opponent(s). The preference rankings of the states can be obtained through the direct ranking of the states and/or based on the options method (Xu et al. 2018a, b). Attitude-based-on-options preference ranking method is also used in conflict management (Xu et al. 2017a, b). Ke et al. (2012) introduced an integrated multicriteria preference ranking method. The present study used an integrated multicriteria preference ranking (Ke et al. 2012) and an attitude-based-on-options approach for preference ranking. First, rankings of the states are generated by using a based-on-option

⁴ Chines President stated Chinese position on the PCA in his address “*Joint Building Human Destiny Community*” in the UN Office of Geneva in January 2017. <http://politics.people.com.cn/n1/2017/01/19/c1001-29033860.html>.

Table 2 Options of decision-makers and feasible states

| DMs | Options | Feasible States | | | | | | | | | | | | | | | | |
|-------|-------------|-----------------|---|---|---|---|---|---|---|----|----|----|----|----|----|----|----|---|
| | | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | |
| US | 1. exit-PCA | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| | 2. rev-T | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 3. reneq | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 4. pca-tip | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 |
| China | 5. bypass | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 |
| | 6. G2 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 |
| | 7. new-G2 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 |
| | 8. C5 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 |
| Label | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | | | |

Table 3 Option statements of the DMs

| (a). Option statements | | | |
|------------------------|--------|---------|--|
| US | EU | China | |
| 1 | -1 | -1 | |
| -2 | | | |
| 2IFF-1 | -2 | -3IFF2 | |
| 3IFF2 | -3IFF2 | -6IFF1 | |
| -4 | 4IFF1 | 8 | |
| 6IF1 | -6IF1 | 7IFF2&3 | |
| -5 | 7 | 5 | |
| -8 | 5 | 4 | |
| -7 | 8 | | |

| (b). Preference based-on options | |
|----------------------------------|---|
| US | 9 > 12 > 8 > 7 > 11 > 10 > 15 > 14 > 13 > 6 > 5 > 4 > 3 > 2 > 1 |
| EU | 2 > 1 > 3 > 5 > 4 > 6 > 14 > 13 > 15 > 11 > 8 > 10 > 7 > 12 > 9 |
| China | 1 > 3 > 2 > 4 > 5 > 6 > 10 > 13 > 7 > 11 > 14 > 8 > 12 > 15 > 9 |

statements approach (Xu et al. 2017a, b). Secondly, states are ranked by using the integrated approach suggested in (Ke et al. 2012) to incorporate the influence power of the DMs. In section 4.4, based on these two state preferences, the attitudinal stability analysis is carried out to test the individual stabilities of the feasible states for each DM.

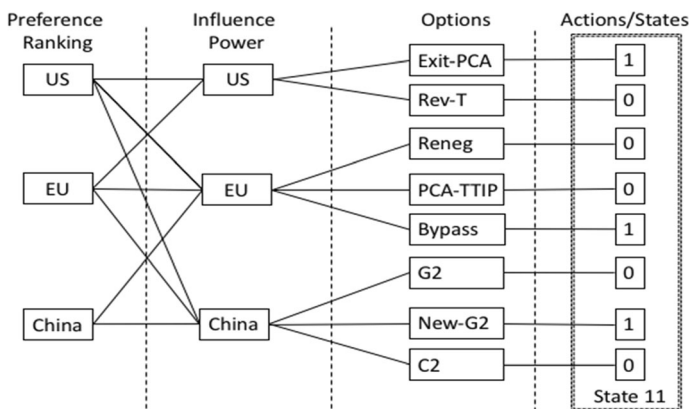


Fig. 4 An adapted AHP model for elicitation of preference ranking based on influence power

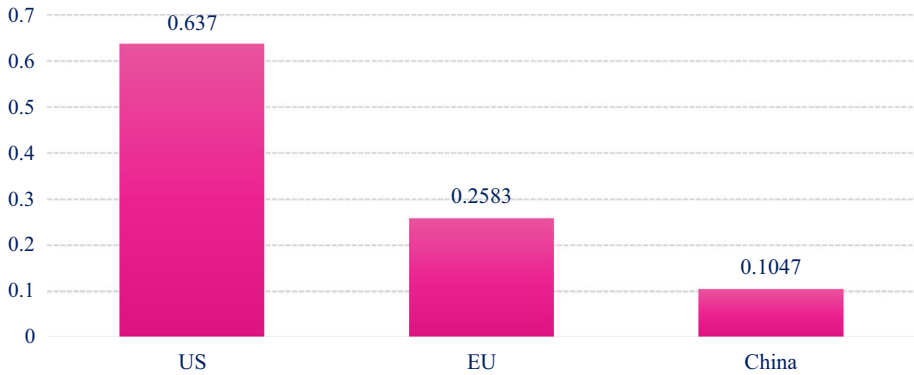


Fig. 5 Influence powers from the US's standpoint

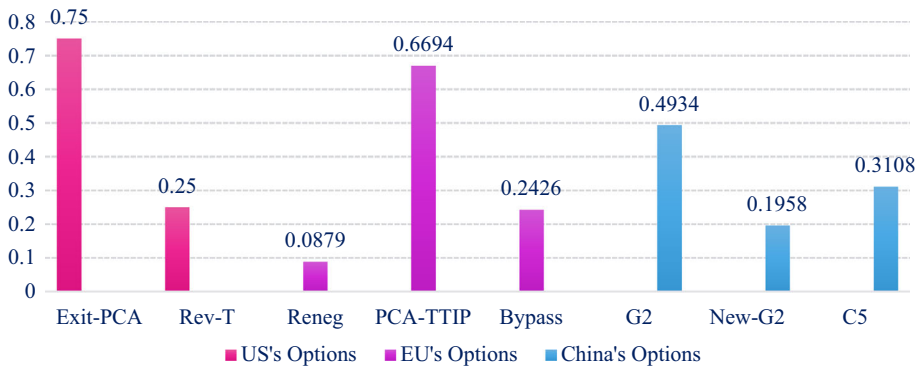


Fig. 6 Comparison matrices for each DM's options from the US's standpoint

4.3.1 Preference ranking of the states based-on-option statements

This section represents how the preferences are generated using attitude based on options. The options statement of each DM and preferences generated based on these option statements are given in Table 3. The options statement of the DM US in column 1 of Table 3 shows that the USA prefers option 1 as it prefers to exit the climate agreement, whereas the EU and China prefer the USA to stay in the agreement and the options statement is -1. The option statements of all DMs show the preferences of the options from the most preferred to least preferred. The option statements of each DM are put into the MRCRDSS software to obtain state ranking from most preferred to least preferred given in the lower panel of Table 3(b).

4.3.2 Preference ranking of the states based on influence powers

Following Ke et al. (2012), based on the DMs and options in Table 1, a hierarchy structure of the conflict model (given in Fig. 4) is used for the elicitation of the influence power-

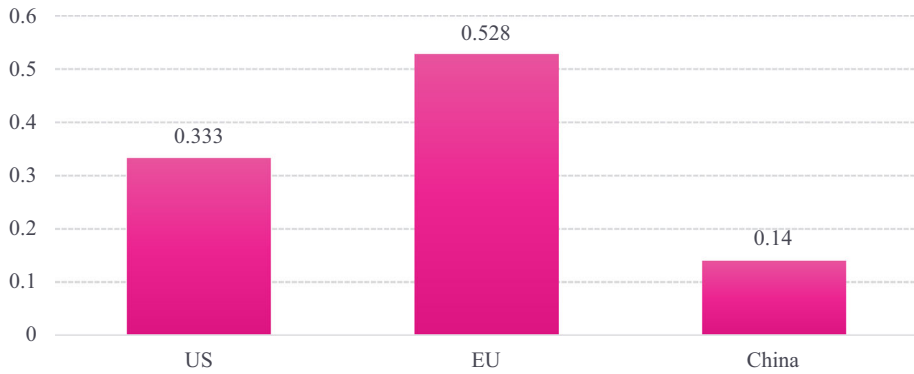


Fig. 7 Influence powers from the EU’s standpoint

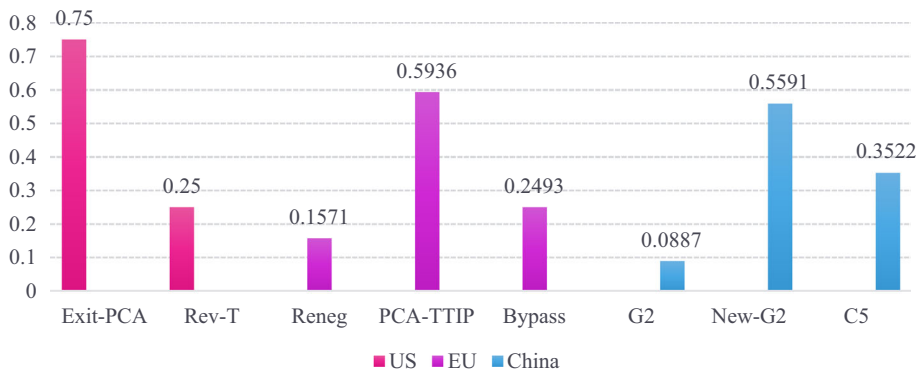


Fig. 8 Comparison matrices for each DM’s options from the EU’s standpoint

based ranking of the feasible states for each DM. The consistencies of all the estimations are confirmed using the recommendations in (Saaty 1995).

4.3.3 US’s standpoint

From the US’s standpoint, at the DM level, the USA is the most powerful DM in the climate agreement conflict following the EU and China. The formed pairwise comparison matrix for influence power in the conflict is given in Figs. 5 and 6. It is because the USA is the second-largest contributor to greenhouse gases. It is the largest economy and the US experts have extensively contributed to climate change research (Zhang et al. 2017a, b).

At the options level, exit-PCA is the first choice for the US based-on-pairwise-comparison matrices for each DM’s options with the US’s viewpoint. The US administration believes that the conditions and targets settled in the PCA are unjust and unfavorable to the USA (Boffey et al. 2017; Carrington 2017; Milman et al. 2017). Article 28 of the climate agreement provides each member of the agreement the liberty to withdraw from the accord. The US president has announced to withdraw from the agreement (Boffey et al.

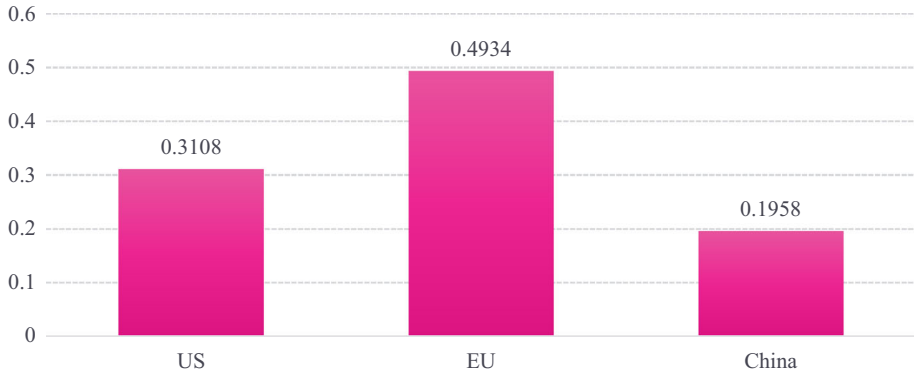


Fig. 9 Influence powers from China’s standpoint

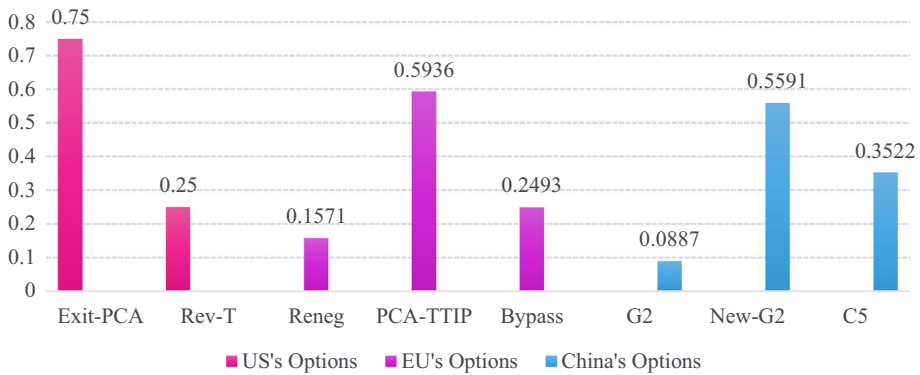


Fig. 10 Comparison matrices for each DM’s options from China’s standpoint

2017; Milman et al. 2017). Regarding the options available to the EU, from the US’s standpoint, PCA-TTIP is preferable for the EU. The USA perceives the renegotiation to revise the targets and NDCs’ contributions to be less preferable to PCA-TTIP. When it comes to China’s options, the USA perceives that the most preferable option for China is to play its promising role hand in hand with the USA. According to the US standpoint, China would prefer C5 over new-G2. It makes the C5 second choice for China from the US perspective.

4.3.4 The EU’s standpoint

The pairwise comparison matrix for the influence power in the climate conflict reveals that the order of the influence power from the most to the least with the EU’s standpoint is the EU, the USA, and China (Fig. 7).

From the EU’s point of view, exit-PCA is the first-choice option (Fig. 8). When it comes to the EU’s own options, the most to least preferred options are *PCA-TTIP*, *Bypass*,

Table 4 Overall ranking weights and state ranking

| | US | | | EU | | | China | | |
|-------|-----------------|---------|---------|-----------------|---------|---------|-----------------|---------|---------|
| | Influence Power | Options | Actions | Influence Power | Options | Actions | Influence Power | Options | Actions |
| | US | 0.637 | 0.750 | 0.478 | 0.333 | 0.250 | 0.083 | 0.311 | 0.750 |
| EU | 0.258 | 0.250 | 0.159 | 0.528 | 0.750 | 0.249 | 0.493 | 0.250 | 0.078 |
| China | 0.105 | 0.088 | 0.023 | 0.140 | 0.157 | 0.083 | 0.196 | 0.072 | 0.035 |
| | | 0.669 | 0.173 | | 0.594 | 0.313 | | 0.649 | 0.320 |
| | | 0.243 | 0.063 | | 0.249 | 0.132 | | 0.279 | 0.138 |
| | | 0.493 | 0.052 | | 0.089 | 0.012 | | 0.163 | 0.032 |
| | | 0.196 | 0.021 | | 0.559 | 0.078 | | 0.297 | 0.058 |
| | | 0.311 | 0.033 | | 0.352 | 0.049 | | 0.540 | 0.106 |

| (b). Preference ranking based on influence power | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|--|----|---|----|---|----|---|----|---|----|---|----|---|---|---|---|---|----|---|----|---|---|---|----|---|---|---|---|---|---|
| US | 15 | > | 13 | > | 14 | > | 12 | > | 10 | > | 11 | > | 9 | > | 7 | > | 8 | > | 6 | > | 4 | > | 3 | > | 5 | > | 1 | > | 2 |
| EU | 14 | > | 13 | > | 5 | > | 15 | > | 4 | > | 6 | > | 2 | > | 1 | > | 11 | > | 10 | > | 3 | > | 12 | > | 8 | > | 7 | > | 9 |
| China | 13 | > | 14 | > | 15 | > | 10 | > | 11 | > | 12 | > | 7 | > | 8 | > | 9 | > | 4 | > | 1 | > | 5 | > | 7 | > | 2 | > | 3 |

and *Reneg*. The EU standpoint about the Chinese options reveals that China would prefer to join the EU in the efforts to climate change and C5 is the second choice for China.

4.3.5 China's standpoint

From China's standpoint, the order of the DM's influence power in the climate agreement conflict from most to least is the EU, USA, and China (Fig. 9). At option levels, China's perspective makes the exit-PCA preferable for the USA (Fig. 10). As for China's own options, China is slightly more powerful in option *new-G2* than that in *G2*. But C5 is the preferable option for China. China can put efforts to build collective efforts rather than *G2*. C5 leadership would be a suitable alternative (Zhang et al. 2017a, b).

However, in addition to its commitment and actions to drop carbon emission, the EU is entwined in multiple crises such as finance, refugees, terrorism, and Brexit. The Brexit and negotiations regarding Brexit can take away the EU's attention from climate agreement. Consequently, the EU may weaken its position to be a global leader in global environmental governance. Moreover, China is a developing country lacking expertise in agenda setting, climate research, and global governance. China would not be able to fill the global leadership vacuum single-handedly after the back away of the USA. The given scenario would be more suitable for rebuilding collective leadership to tackle the challenges of GCG (Zhang et al. 2017a, b). So, China prefers to rebuild a collective leadership and perceives C5 as a better option for the efforts for climate change.

4.3.6 Overall ranking

After obtaining the pairwise comparison matrices from each DM's standpoint, the results are aggregated and listed in Table 4. The weights for the Actions (States) are estimated by multiplying the respective influence power of each DM by the option weight. For example, the action weight (stage weight) for the USA selecting option *Exit-PCA* is $0.637 \times 0.75 = 0.478$.

All the feasible states are alternative strategies. These strategies are ranked according to the weights estimated in the AHP framework for each strategy with the standpoint of each DM. The weight of each feasible state for each DM is obtained as the weight of state 11 for the USA is calculated as $1 \times 0.478 + 0 \times 0.159 + 0 \times 0.023 + 0 \times 0.173 + 1 \times 0.063 + 0 \times 0.052 + 1 \times 0.021 + 0 \times 0.033 = 0.561$. This numerical weight value is estimated for each state for each DM according to its standpoint. After obtaining these numerical weights, the ordinal preference ranking of these states for each DM is obtained given in the lower panel in Table 4. These preference rankings can be put manually in the MRCRDSS for further attitudinal stability analysis which provides individual stability of the states and equilibrium information under different stability definitions.

A significant change in DMs' state preferences is notable when the influence power of the DMs from each DM's standpoint and pairwise comparison of each DM's options from each DM's standpoint are incorporated to generate preference rankings of the states. It makes states 15, 14, and 13 to be the most preferred state for the USA, EU, and China, respectively. The point worth noting is the most preferred states are the extreme strategies that each prefers the state having the option for the respective DM has more influence power. These changes in the preference rankings of the states may have a significant impact on the equilibrium outcomes of the climate agreement issue.

4.4 Stability analysis

The present conflict analysis study utilizes two different preference rankings for stability analysis of the feasible states. Firstly, preferences generated from attitude-based options (see Panel (b) in Table 3) are used to carry out stability analysis and trace out the possible equilibrium states under different attitudes of the DMs. Secondly, the preference generated from the adapted approach while incorporating the influence power of the DMs is given in panel (b) of Table 4. The results of the stability analysis are summarized in Fig. 11.

4.4.1 Attitudinal stability analysis with the preferences based on options

The conflict analysis under the preferences based on options has been carried out while considering six attitude matrices. The sign indicates the stability of the states under the attitude-based-on-options. The results unveil states 4, 5, 6, and 13 as equilibrium states when the USA and the EU have a positive attitude for themselves but a negative attitude for each other (Fig. 11). In this case, China has a positive attitude for itself but a neutral attitude toward other DMs. There is no change in the equilibrium states if even the EU changes its attitude from negative to neutral for the USA ($a_{EU} = 0$) having other DMs attitude unchanged. However, in addition to the former four equilibrium states, state 14 becomes stable for all DMs when China has a positive attitude toward the EU ($a_{CE} = +$) irrespective of the EU’s negative attitude toward the USA and the US’s negative attitude toward the EU.

States 4, 5, 6, and 13 are still the equilibrium states when all the DMs have a positive attitude for themselves but neutral attitudes toward other DMs in the conflict model. State 13 implies that the USA backs out of the climate agreement. In this case, the EU’s strategy is to oppose any TTIP with the USA and join China to collaborate in the C5 option as a suitable strategy to strengthen the global leader in the efforts to combat climate change. This strategy is suitable for the USA as state 13 is preferred to other equilibrium states 4, 5,

| Attitudes | | States | | | | | | | | | | | | | | |
|-----------|--|--------|---|---|---|---|---|---|---|---|----|----|----|----|----|----|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| 1. | $a_{UU} = +$ $a_{UE} = -$ $a_{UC} = 0$ $a_{EU} = -$ $a_{EE} = +$ $a_{EC} = 0$ $a_{CU} = 0$ $a_{CE} = 0$ $a_{CC} = +$ | | | | ⊕ | ⊕ | ⊕ | √ | | | | | | ⊕ | | |
| 2. | $a_{UU} = +$ $a_{UE} = -$ $a_{UC} = 0$ $a_{EU} = 0$ $a_{EE} = +$ $a_{EC} = 0$ $a_{CU} = 0$ $a_{CE} = 0$ $a_{CC} = +$ | | | | ⊕ | ⊕ | ⊕ | | | | | | | ⊕ | | |
| 3. | $a_{UU} = +$ $a_{UE} = -$ $a_{UC} = 0$ $a_{EU} = -$ $a_{EE} = +$ $a_{EC} = 0$ $a_{CU} = 0$ $a_{CE} = +$ $a_{CC} = +$ | | | | ⊕ | ⊕ | ⊕ | √ | √ | | | √ | | ⊕ | ⊕ | |
| 4. | $a_{UU} = +$ $a_{UE} = -$ $a_{UC} = 0$ $a_{EU} = 0$ $a_{EE} = +$ $a_{EC} = 0$ $a_{CU} = 0$ $a_{CE} = +$ $a_{CC} = +$ | | | | ⊕ | ⊕ | ⊕ | | | | | | | ⊕ | ⊕ | |
| 5. | $a_{UU} = +$ $a_{UE} = 0$ $a_{UC} = 0$ $a_{EU} = 0$ $a_{EE} = +$ $a_{EC} = 0$ $a_{CU} = 0$ $a_{CE} = 0$ $a_{CC} = +$ | | | | ⊕ | ⊕ | ⊕ | | | | | | | ⊕ | | |
| 6. | $a_{UU} = +$ $a_{UE} = +$ $a_{UC} = 0$ $a_{EU} = +$ $a_{EE} = +$ $a_{EC} = 0$ $a_{CU} = 0$ $a_{CE} = 0$ $a_{CC} = +$ | ⊕ | ⊕ | | ⊕ | ⊕ | | ⊕ | ⊕ | | ⊕ | ⊕ | | ⊕ | ⊕ | |

Note: U: United States, E: European Union, C: China
 ⊕ Equilibrium under preference based on options, √ Equilibrium under preference based on influence power

Fig. 11 Attitudinal stability analysis: results summary

and 6 for the USA (see Table 3). However, this strategy is less preferred for the EU and China as for both China and EU states 4, 5, and 6 are more preferred to state 13 (see Table 3). When China has a positive attitude toward the EU, state 14 is also an equilibrium strategy. This implies that if the USA backs out of the PCA, the EU and China join hands and strengthen the global leadership by filling the vacuum of effective leadership in global environmental governance. State 14 is also preferable for the USA as $14 > 13$. The same is true for the EU but for China $13 > 14$. States 4, 5, and 6 are common equilibrium states under all attitude matrices. These strategies imply that the USA revises the NDCs in PCA and the EU agrees to renegotiate the terms. As the US administration claimed to renegotiate the terms in their favor. These strategies are less preferred for the USA as states $(13, 14) > (4, 5, 6)$ for the USA (see Table 3). However, these states are preferable for the EU and China as they oppose the US's decision to back out of the climate agreement. From the Chinese perspective, state $4 > (5, 6)$ as China's stand would be to strengthen global leadership by playing its role in the efforts to climate change in the C5 leadership format. But the EU would prefer New-G2 with China even if there is any renegotiation with the USA. The chances of the renegotiation are very rare as the EU has already categorically refused any renegotiation on the agreed-upon global agreement.

The change of attitude of the USA and the EU from negative/neutral to positive opens the avenues of more possible outcomes of the conflict. In addition to equilibrium states 4, 5, 13, and 14, states 7, 8, 10, and 11 also deemed to be equilibrium states when the USA and the EU have a positive attitude toward each other ($a_{UE} = +$ and $a_{EU} = +$). States 7 and 8 specify the strategy that the USA chooses to back out of the climate agreement. The difference between the two states regarding the Chinese role in international environmental governance is either to collaborate with the EU in the C5 leadership regime (state 7) or join hands with the EU as a *New-G2* leadership. State 8 is preferable for the USA and EU than the state 7. However, state 8 is less preferred to state 7 for China (see Table 3). States 10 and 11 specify that the USA backed out of the agreement (*Exit-PCA*) and the EU chose to collaborate directly with the states and other industries and corporations bypassing the US administration. In the meanwhile, China adopts the strategy C5 (state 10) or chose *New-G2* with the EU for effective leadership in efforts to climate change.

4.4.2 Attitudinal stability analysis with preferences based on influence power

The attitudinal stability analysis under the influenced-power-based preference rankings is also carried out while considering different attitude matrices of the DMs (summarized in Fig. 11). The sign in the figure below the respective state(s) indicates the stability of the respective state for each DM. State 4, 7, and 13 are the equilibrium states when the USA and EU have a negative attitude toward each other ($a_{UE} = -$ and $a_{EU} = -$), and China has a neutral attitude toward them ($a_{CU} = 0$ and $a_{CE} = 0$). State 7 is an unfavorable outcome as it implies that the USA withdraws from the PCA (*Exit-PCA*) and the EU and China move forward to strengthen global leadership in the shape of C5 by filling the effective leadership vacuum in the efforts of global environmental governance. When the EU turns its negative attitude to neutral ($a_{UE} = 0$) but the USA still has a negative attitude ($a_{UE} = -$), state 4 and 13 are concluded to be the equilibrium states.

The stability analysis with attitude matrix 3 reveals multiple equilibrium states. If $a_{UE} = -$ and $a_{EU} = -$ but China changes its neutral attitude to positive toward the EU ($a_{CE} = +$), states 4, 5, 7, 8, 11, 13, and 14 become stable for each DM. In this case, states 7, 8, and 11 are new equilibrium states. State 7 is already discussed. The only difference

between states 7 and 8 is that state 8 implies the EU and China lead the efforts (*New-G2*) in global environmental governance rather than C5. However, state 11 is different from these two. Moreover, state 11 is preferred to states 7 and 8 for all DMs in the climate agreement conflict model according to the influence power-based preference in Table 4. This state implies that the USA backs out the climate agreement (*Exit-PCA*) and the EU bypasses Washington and collaborates directly with the states and other industries, multinational corporations, and business entities (*Bypass*) to curtail carbon emission to protect the global environment. Moreover, join hands with China (*New-G2*) and lead the global environmental governance regime.

States 4, 5, 13, and 14 are concluded to be equilibrium states when the USA has a negative attitude toward the EU ($a_{UE} = -$), the EU has a neutral attitude toward the USA ($a_{UE} = 0$), and China has a positive attitude toward the EU ($a_{CE} = +$) but a neutral attitude toward the USA ($a_{CU} = 0$). The attitudinal stability analysis is also carried out while considering the neutral attitude of all DMs toward each other to analyze the difference between the impact of preferences on the outcomes. States 4 and 13 are the equilibrium states when all the DMs have a positive attitude for themselves but a neutral attitude toward their opponents. However, the stability analysis unfolds states 5, 10, and 14, in addition to states 4 and 13, when the USA and the EU have a positive attitude toward each other, but China has a neutral attitude toward them (attitude matrix 6 in Fig. 11).

5 Discussion

The present conflict analysis generates the preference ranking by using the power of the DMs to influence the conflicting situation and traces out the stability of each feasible state under the attitudinal stability concepts. It incorporates the behavioral patterns into consideration coupled with the combination of their standpoints regarding their respective power to influence the conflicting situation in global environmental governance and their perceptions about the options preferences with the standpoint of each DM for each DM. Preferences play an important role in the determination of the solution to the conflict. When the preferences are generated with attitude based on options, the USA prefers the states showing the strategies to *exit* the PCA to the strategies to stay in the agreement. As the states $(7, 8, 9, 10, 11, 12, 13, 14, 15) >_{US}(1, 2, 3, 4, 5, 6)$. But the opposite is true for the EU and China as $(1, 2, 3, 4, 5, 6) >_{EU\&China}(7, 8, 9, 10, 11, 12, 13, 14, 15)$ (see Table 3). This shows that the EU and China want the USA to be a part of the PCA for the effective implementation of the climate agreement for the effectiveness of the GCG. However, if the USA backs out of the agreement, the strategies $(11, 13, 14, 15) >_{EU}(7, 8, 10, 12)$ and $(7, 10, 11, 13) >_{China}(8, 9, 12, 14, 15)$. The stability analysis results under the attitude-based preferences reveal states 4, 5, 6, and 13 common equilibrium states with attitude matrices 1–5. States 4, 5, and 6 epitomize the states that the USA stays in the agreement and revise the targets, whereas the EU agrees to renegotiate. However, the difference between these three states is G2, *New-G2*, and/or C5. State 13 exemplifies the extreme strategy that the USA backs out of the agreement and the EU has no TTIP with the USA. In addition to this, China opts for the strategy to strengthen C5 leadership to achieve the goals of the agreement. When the USA and the EU show a positive attitude toward each other and China has a neutral attitude toward each other, in addition to states 4, 5, 6, and 13, there are 7, 8, 10, 11, and 14 equilibrium states. These states represent the same strategy when it comes to the USA, but states 7 and 8 imply no response from the EU. However, states 10 and 11 imply that the EU would respond to the US back-out and choose to bypass

Washington and collaborate directly with the states and enterprises in the efforts of adaptation and mitigation to climate change.

When the influence power and perception about the options of each DM with its perspective are considered, there was a significant change in the preference rankings of the states. Each DM prefers the state containing the options that it has more influence power at option(s) that it perceives the opponent(s) have more influencing power at. For example, from the US standpoint, it has the most influencing power in the climate agreement conflict. When it comes to the options, *Exit-PCA*, *PCA-TTIP*, and *G2* are preferred options for the USA, the EU, and China, respectively, from the US's standpoint (see Fig. 4). This makes state 15 to be the most preferred state for the USA (see Table 4). The stability analysis under the influence power-based preferences unveils states 4 and 13 as common equilibrium states under all attitude matrices considered in the analysis. In addition to states 4, 5, 6, 13, and 14, the stability analysis under influence power-based preferences and with attitude matrix 3 also unfolds states 7, 8, and 11 as equilibrium states. However, states 7 and 8 are more unlikely to be the equilibrium states as the EU would respond to any US move regarding the implementation of the PCA. States 4 and 13 are common equilibrium states with both preference ranking approaches with neutral attitudes of each DM toward other DM(s) in the modeled conflict. However, more probable outcomes are revealed when the USA and the EU turn their neutral attitudes toward positive for each other, and China has a neutral attitude toward them. State 10 is the only state strategy that is the new equilibrium under both preference rankings (see Fig. 11).

Each equilibrium state strategy has its prospects and implications on the global environmental governance regime. The equilibrium states 4 and 5 mean the USA stays in the climate agreement but it revises the targets and contributions that it has already pledged in the PCA. Though the equilibrium states mentioned above show that the EU agrees to negotiate with the USA to revise the targets and contributions for adaptation and mitigation, but it seems more unlikely as the EU has strongly rejected this option. If in case it happens, the Chinese strategy would be to engage the EU in *New-G2* or *C5* for the robust leadership on the way to global environmental governance. States 13 and 14 imply if the USA backs out of the PCA, the EU would reject the possibility of transatlantic trade and investment agreement with the USA. However, the EU and China would have to lead the world in the efforts to protect the global environment whether it is *New-G2* or *C5* leadership. However, the *New-G2* option would hardly fill the vacuum after back-out by the USA from the agreement. The US's back-out would be a "strategic penalty" and would damage the US national security (Barclay 2017). The USA already did shrink the international responsibility on climate change when it decided to withdraw from the Kyoto Protocol in 2001.⁵ Similarly, now the decision to withdraw would strain the US's liberty in economic and strategic cooperation with its partners. Moreover, it would affect the US strategic strength vis-à-vis its competitors in the world. It would allow the US's adversaries to expand its influence in the Asia-Pacific, the Middle East, North Africa, and the Arctic (Ref. Barclay, 2017). However, the biggest enterprises⁶ consider the PCA a good deal for them. Moreover, it also gives the USA the ability take part in discussions to protect the US's economic

⁵ Leber, Rebecca discusses "Trump has no idea what he just did or the backlash that awaits" <https://www.motherjones.com/environment/2017/06/trump-will-regret-leaving-paris-climate-deal-0/>.

⁶ US fortune 500 companies public support for the Paris Agreement. https://www.eenews.net/assets/2017/05/26/document_daily_02.pdf.

and environmental interests in the future⁷ Though the USA considers that PCA gives China and India an economic leg up on the USA as their cheap coal puts the US's manufactures at a disadvantage, the USA, with the back-out decision, would no longer be able to lead on the voyage to climate change and would let other countries especially China to steer the ship. China has already emerged as a leader in green energy and technology, and it is expected that China would reach its PCA targets early.⁸

From China's perspective, it would prefer to put its efforts to rebuild collective leadership by replacing China-USA G2 with a collective leadership of Climate 5 (C5) comprising China, the EU, India, Brazil, and South Africa. C5 leadership would be a suitable alternative (H. Bin Zhang et al. 2017a, b). State 10 is likely to be the equilibrium state for all the DMs if the USA backs out the PCA. The EU could choose to directly cooperate with the states and business enterprises bypassing Washington. The states, cities, investors, and corporations have already shown their interest and consensus on efforts to climate change (Milman et al. 2017; Zhang et al. 2017a, b) The US's administration decided to back out of the PCA has also been disapproved by the blue-chip companies including Apple, Ford, Microsoft, and Facebook. Moreover, several US states have also vowed to ignore Washington's decision on PCA (Boffey et al. 2017). As far as the effective leadership in the efforts for an productive global environmental governance is concerned, the EU and China would strongly encourage C5 leadership. The collective leadership would include the major emitters and would make them involve and act collaboratively. The new featured collective leadership would be diversified that would not only facilitate cooperation between the developed and developing economies, but their engagement would also facilitate North–South cooperation in GCG. Moreover, it would release some pressure on China to be the next leader as the expectations are disproportionately very high. More importantly, collective leadership and effort would be more fruitful rather than single-country lead governance (Bin Zhang et al. 2017a, b). Collective efforts of the governments could be beneficial in paving the way for sustainable development. Research and Development (R& D) help increase productizing and regional productivity paving the way for sustainable development (Aldieri et al. 2018). Government policy can play a critical role in knowledge transfer and thereby sustainable development through the promotion of knowledge complementarity coordination between environmental fields (Aldieri et al. 2020).

6 Conclusion

The present study is an attempt to propose a negotiation strategy for the resolution of the climate agreement conflict that emerged due to the US back-out from the climate agreement. As the mechanism of implementation of the Paris Agreement is based on transparency, nonpunishment, and nonconfrontation, there is an inherent tendency of noncompliance by any member state. According to the agreement, each member country is supposed to fully implement the NDCs as pledged in the agreement. In the very interdependent world, any defiance from the agreement would affect not only the defying

⁷ Exxon and Conoco reiterate support for Paris climate deal. <https://www.bloomberg.com/news/articles/2017-05-31/exxon-conoco-back-paris-climate-deal-as-trump-weighs-pact-exit>.

⁸ Lavelle, Marianne discusses how “China, India to Reach Climate Goals Years Early, as U.S. Likely to Fall Far Short”. <https://insideclimatenews.org/news/15052017/china-india-paris-climate-goals-emissions-coal-renewable-energy>.

economy but also the rest of the world. Any change in the domestic policies of an economy consequent upon any change in government or any major policy shift would hamper the effective implementation of the climate agreement.

Similarly, the US back-out from the agreement is likely to affect emission space, carbon price, macroeconomic conditions of all the member economies. This would create a conflict of interest and conflict between the member countries. Furthermore, it would adversely affect the implementation of the climate agreement in its true spirit and would jeopardize the efforts to combat climate change by creating a leadership vacuum for global climate governance. The EU, the USA, and China played an important role in the process of making the PCA. The attitudes of the leading economies in decision-making for climate governances and their influence power have effects on their course of actions to adaptation and mitigation.

Attitudes of the DMs and their influence power affect their preferences and thereby the outcomes of the climate governance conflict. The preferences with attitude based on options and preferences based on the influence power of the USA, the EU, and China are obtained. The analyses of preferences with two different approaches unfold that the influence power of the DMs, their standpoint about the influence power of the DMs in the conflict, and the preference of their options with the standpoint of each DM significantly affect the preference ranking of the states when compared to the preferences generated with the attitude-based-on-options approach. These preferences are used to test the stability of the strategy states. The attitudinal stability analysis reveals that influence power affects the equilibrium outcomes of the climate governance conflict. Different equilibrium state strategies have different implications for climate governance. With both preference ranking approaches, it is common that the DMs showing a negative attitude lead to more unfavorable outcomes. However, when the DMs have positive attitudes toward each other, it opens more avenues for the solution of the conflict. But, when the influence power of the DMs is considered in the attitudinal stability analysis, the equilibrium states are obtained having the options in which DM has more influence power.

A different set of equilibrium strategies have been obtained under a different set of attitudes and influence power. In the first set of equilibrium states, the USA stays in the agreement and the EU agrees to negotiate with the USA. The USA has proclaimed to stay or re-enter the agreement but on favorable terms. In this way, China and the USA may lead the efforts to climate change with the EU. This strategy would have been effective and efficient in the implementation of the climate agreement. As, the USA is the largest and technologically advanced economy coupled with the enriched advancement in the research regarding mitigation and adaption. Moreover, the USA has more influencing power and a global leader and has its influence on the world economy. This strategy might have been a suitable strategy, but the USA has announced the back-out. Second, with the US back-out, the EU has also the strategy to rule out any trans-Atlantic trade and investment agreement with the USA until the USA complies with the climate agreement.

But these strategy options may have more serious implications if there are any possible repercussions from the US side. In addition to this, the EU joins hands with China to lead the world on the way to adaption and mitigation to protect the environment not only for the current generation but also for the future generations. Third, the EU bypasses Washington and joins hand directly with states, cities, and businesses in the efforts to climate change. As far as global environmental governance is concerned, China may play its leading role in the efforts to climate change. In this regard, China has two options: join the EU in New-G2 leadership or put its efforts to collaborate to make global shared leadership in the shape of C5 leadership format. China may consider the C5 leadership format more suitable as it

makes possible the representation of greater regional economies to put efforts in adaptation and mitigation.

It is more likely that the US withdrawal would jeopardize the achievement of the targets set in the PCA. The withdrawal upsets the process of global climate cooperation by destabilizing and undercutting GCG. However, climate change is writing on the wall that it is unavoidable. Its impacts and intensity could be reduced while reaching the PCA targets of carbon emission peaks as spelled out in the agreement. Serious mitigation and adaptation efforts are necessary irrespective of any attitude or changes in attitude, influence power, and power preferences of the decision-makers. It is a collective responsibility of the inhabitants of this habitable planet.

The study strengthens the argument that neither the attitude nor the power would work for the betterment and protection of climate and ecosystem unless the attitude and power are used as the tools or motivation to fulfill the commitments and pledges made in the climate agreement. The developed economies need to play a pivotal role as they have already enjoyed higher levels of economic growth and quality of life at the cost of the global environment more than the developing and underdeveloped economies. Modern economies have the resources and capacity to find new ways of environmentally friendly technologies. Besides, poor and developing economies have a long way to go to sustainable development. Unfortunately, these economies are more vulnerable to climate change and global warming. These economies not only need resources, technology, knowledge, and skills to set their growth trajectory but also the resources for mitigation and adaptation. Collective, collaborative, and efficient leadership is indispensable for global environmental governance. The current study used tools of the GMCR framework to analyze the post-defiance scenarios related to GCG issues. It considered three major contributors to global carbon emissions however there are other major economies such as Japan, India, Brazil, Russia, to name a few, that can play important role in the efforts to improve GCG. Moreover, the preference ranking methodologies could also be utilized and enriched by introducing and incorporating other MCDA approaches such as TOPSIS, fuzzy-AHP, Fuzzy TOPSIS, VIKOR, Fuzzy-VIKOR, to name a few. The power of a DM in a certain condition can change the scenario or course of action of other DM(s) due to inherent power asymmetry. Being a common feature of real life, power asymmetry plays important role in decision-making and implementation. It is imperative to examine the decision-making behavior of the DMs in the context of issues of fundamental importance such as climate change and global warming.

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