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PONDARA on Ukraine Conflict
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PONDARA is an AI-powered risk management system developed to enable our clients to achieve value-based growth by improving strategies, operating performances, and risk management.

Given the grave global concern surrounding the Ukraine conflict, we are sharing a report from a workgroup (WG) tasked with using the system to explore the application of game theory in the conflict, particularly focusing on decision-making and strategic interactions among multiple agents.

Functions of the Workgroup

The workgroup's primary function is to apply Noncooperative Game Theory (NCGT) to analyse the strategic interactions among the key players involved in the Ukraine conflict. This involves:

1. Identifying players and their objectives:
   The WG identifies the key players in the conflict—Ukraine, Russia, EU+UK, America, and China—and their respective objectives.

2. Modelling strategic interactions:
   Using NCGT, the WG models the strategic interactions among these players, considering the sequence of moves, available actions, potential outcomes, and payoffs.

3. Analysing Nash Equilibria:
   The WG identifies Nash Equilibria to determine the optimal strategies for each player, where no player can improve their payoff by unilaterally changing their strategy.

4. Risk identification and mitigation:
   The WG identifies key risks associated with the conflict but reserves mitigation measures required. PONDARA's patented technology for risk evaluation and management can be made available to respective players and interested parties upon request.

Proposed Objectives

Based on information inputs up to 4 Mar 2025, the system returns a set of proposed objectives for the respective players: Ukraine, Russia, EU+UK, America, China.

- regaining sovereignty and minimizing damage (Ukraine),
- securing strategic interests (Russia),
- supporting Ukraine's sovereignty (EU+UK),
- maintaining geopolitical influence (America), and
- enhancing diplomatic influence (China).

Optimal Strategies per Nash Equilibria

The following is a Nash Equilibria payoff summary based on inputs, analysis and outputs – see workings in the later part of this report.

Equilibrium	Ukraine (U)	Russia (R)	EU+UK (E)	America (A)	China (C)
1	-2	-1	-1	-1	0
2	1	-1	1	1	0
3	-1	1	1	1	0

According to the summary, Ukraine may employ a **mixed strategy** based on strategies identified in Nash Equilibria 2 and 3. Russia, may employ the same pure strategy identified in Nash Equilibria 2 and 3. EU+UK, America, and China may employ pure or mixed strategies identified in Nash Equilibria 2 and 3. See details of this strategy profile in the workings.

Nash Equilibrium 1 should be avoided all together, as it means the conflict will continue indefinitely until at least one of the players surrender or is willing to change its position.

Risks requiring actions

The system also returns the following heat matrix showing the concentration of 15 unacceptable risks requiring immediate action. The pattern of risk concentration will change following effective implementation of mitigation measures.

Game Theory Nexus
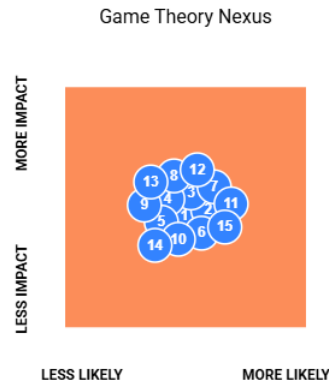
1. **Continued Civilian Casualties**: Prolonged conflict could result in ongoing civilian casualties, increasing humanitarian crises and international condemnation.

2. **Economic Disruption**: The ongoing war could lead to significant economic disruptions, harming Ukraine's infrastructure, industries, and overall economic stability.

3. **Loss of International Support**: Over time, Ukraine might lose international support from allies like the EU and the US, especially if the conflict drags on without a clear resolution.

4. **Economic Sanctions and Isolation**: Continued aggression could lead to further economic sanctions and isolation from the international community, damaging Russia's economy and global standing.

5. **Military Overreach**: Extended military operations could overstretch Russia's military capabilities and lead to strategic vulnerabilities.

6. **Internal Political Instability**: Prolonged conflict and international backlash could lead to internal political instability and dissent within Russia.

7. **Economic Burden**: Providing continuous military and financial aid to Ukraine could strain the EU's economy, leading to public and political opposition.

8. **Political Fracture**: Differences in member states' opinions on supporting Ukraine could lead to political fractures within the EU.

9. **Escalation Risk**: Increased involvement in the conflict could escalate tensions and potentially draw EU nations into direct confrontation with Russia.

10. **Domestic Opposition**: Continued involvement in the Ukraine conflict could lead to domestic opposition and reduce public support for the administration's policies.

11. **Economic Impact**: Prolonged conflict involvement could impact the US economy through increased defence spending and potential loss of trade opportunities.

12. **Geopolitical Strains**: Efforts to maintain influence might strain relations with non-aligned countries or adversaries, complicating international diplomacy.

13. **Neutrality Perception**: China's perceived neutrality might be questioned, leading to distrust from both Russia and Ukraine, impacting diplomatic relations.

14. **Economic Vulnerability**: China's economic opportunities might be affected by the conflict due to sanctions or disrupted trade routes.

15. **Diplomatic Backlash**: Efforts to leverage the situation could result in diplomatic backlash from Western countries, affecting China's international relationships.

Workings

The following is a summary of the workgroup's inputs and the return of PONDARA's analysis and outputs for those interested in the process of deriving the above findings.

Contextual Information Inputs, Analysis and Outputs

The workgroup firstly input a detailed description of Game Theory, as follows:

1. Individual Decision Making and Economic Settings

Game theory studies how individuals make decisions in both abstract problems and specific economic contexts. It examines how the simultaneous behaviours of self-interested individuals and firms generate outcomes in market economies.

2. Multi-Person Interactions (MI) and Strategic Interdependence (SI)

A central feature of game theory is the modelling of multi-person interactions, where the presence of strategic interdependence is crucial. In such settings, each agent's payoff (utilities or profits) depends not only on their own actions but also on the actions of others. This is referred to as a multi-person interaction with strategic interdependence (MSI2).

3. Noncooperative Game Theory (NCGT)

The primary tool for analysing these interactions is Noncooperative Game Theory (NCGT). NCGT focuses on **how cooperation may emerge as rational behaviour of self-interested players even in the absence of binding agreements**.

4. Key Concepts and Elements

Strategy and Winning: Agents are concerned with devising strategies to maximize their payoffs.

5. Basic Elements of a Game

Players: The individuals or entities involved in the game.
Rules: The sequence of moves, what players know, and what actions they can take.
Outcomes: The possible results of the game based on the actions taken by the players.
Payoffs: The utility or profit each player receives from the outcomes.

6. Extensive Form Representation

A game can be represented in extensive form using a game tree, which captures:

- Who moves when
- What actions each player can take
- What players know when they move
- The outcomes as a function of the actions taken
- The players' payoffs for each possible outcome

7. Examples of Games

- Matching Pennies: A zero-sum game where two players simultaneously put a penny down, and the payoffs depend on whether the pennies match.
- Tick-Tack-Toe: A sequential game where players take turns placing X or O on a board, aiming to get three in a row.
- Orientation: A coordination game where players must choose a meeting place without prior communication.

8. Information Sets and Perfect Information:

- Information Sets: Represent the possible circumstances in which a player might be called to move.
- Perfect Information: A game is one of perfect information if each information set contains a single decision node. Otherwise, it is a game of imperfect information.

9. Random Moves and Nature:

Games may include an element of chance, represented by random moves of nature.

10. Common Knowledge:

It is a basic postulate of game theory that all players know the structure of the game, know that their rivals know that they know it, and so on. This is referred to as common knowledge.

11. Mathematical Representation:

In addition to being depicted graphically, game theory can be described mathematically. The notations are explained in the context of an enterprise carrying on business with management and staff members working together to achieve growth in profits or enterprise value, outcomes that can be formally defined. It is helpful to learn the forms (structures and relations) and elements (essential

considerations) to improve deliberation in decision-making (arriving at a decision and seeing it through). The mathematical representation of a game in normal form can be summarized as follows:

$\Gamma_N = [I, \{S_i\}, \{u_i (\cdot)\}]$ or $[I, \{\Delta S_i\}, \{u_i (\cdot)\}]$ and $S_i(H) \in C(H)$

- Γ_N: A game (e.g. business) with I players who interact to maximize utility (payoff).
- I: The group of players identified in the game.
- $I = \{I_1, I_2, I_3 \dots I_I\}$, or $\{I_i\}$: The group of players identified in the game.
- I_i: Player i.
- I_{-i}: Other players not specifically identified, rivals or unknown players.
- I_0: Nature, environment, act of God. Hence, all players, whether known or unknown, together with nature = $\{I_i, I_{-I}, I_0\}$.
- S_i: A group of strategies that player i employs in a deterministic manner.
- $s_i \in S_i$: A strategy (a course of action) that player i chooses among available strategies.
- ΔS_i: A group of strategies that player i may randomize, permitting mixed strategy.
- H: A set of information, circumstances player i faces at a decision point, and $H \in \{H_i\}$.
- $\{H_i\}$: Sets of information available to player i and $\{H_i\} \subseteq \mathscr{H}$, all available information.
- C(H): All possible actions, based on knowledge of information set H.
- $S_i(H)$: Strategies player i is expected to deploy as a function of information H.
- u_i: Utilities or payoffs that player i earns as a valued outcome.
- $\{u_i (\cdot)\}$: A collection of payoff functions $u = \{u_i(\cdot), \dots u_I (\cdot)\}$.
- $u_i (s_i ,s_{-i})$: Valued outcome to player i depends on moves of oneself and every other player.
- $u_i (s_i ,s_{-i}) > u_i (s'_i ,s_{-i})$ and $s_i \neq s'_i$ => s_i is better than s'_i.
- $u_i (s_i ,s_{-i}) > u_i (s'_i ,s_{-i})$ for all s_{-i} => s_i is a strictly dominant strategy or s_i dominates s'_i.
- $u_i (s'_i ,s_{-i}) > u_i (s_i ,s_{-i})$ for all s_{-i} => s_i is a strictly dominated strategy or s'_i dominates s_i.
- $u_i (s'_i ,s_{-i}) \geq u_i (s_i ,s_{-i})$ for all s_{-i} and $u_i (s'_i ,s_{-i}) > u_i (s_i ,s_{-i})$ for some s_{-i} => s_i is a weakly dominated strategy.
- $u_i (s_i ,s_{-i}) \geq u_i (s'_i ,s_{-i})$ for all $s'_i \in S_i$ and for every player i => the strategy profile $s = (s_1, s_2 \dots s_I)$ is in a Nash equilibrium.
- Bayesian game is summarized as $[I, \{S_i\}, \{u_i(\cdot)\}, \Theta, F(\cdot)]$, $u_i(s_i, s_{-I}, \theta_i)$, where $\theta_i \in \Theta_i$, where Θ is a set of random variables, and $F(\cdot)$ is respective probability distributions.

Application of NCGT to the Ukraine Conflict

Structure of the Conflict per NCGT

Players:

- Ukraine (U)
- Russia (R)
- EU+UK (E)
- America (A)
- China (C)

Rules - Sequence of Actions:

1. R considers U's geopolitical inclination a threat to its security.
2. R sent its forces into U in 2022, and a war thus erupted.
3. E and A have been providing U military aids except for ground troops.

4. E and A have also imposed embargoes on R.
5. R has occupied 20% of U's territories since.
6. C remains neutral but has been providing limited support.
7. There was a change in administration in A following its presidential re-election in 2024.
8. Since then, A has been in close talks with R.
9. A is trying to convince U to accept a ceasefire.
10. U is only willing to accept with A's security guarantee to bring about an enduring peace.
11. The negotiation between A and U broke down, A is considering withholding aids to U.
12. E forms a "coalition of the willing" and increases spending on defense.
13. E declares continued support for U and tries to convince A to join its support for U.

Actions Available to Each Player

Ukraine (U):
1. Continue fighting with the current level of support from E and A.
2. Accept a ceasefire without A's security guarantee.
3. Seek additional support from other international players.
4. Negotiate directly with R for a ceasefire or peace agreement.

Russia (R):
1. Continue the conflict and consolidate occupied territories.
2. Agree to a ceasefire and negotiate terms with U.
3. Escalate the conflict by increasing military operations.
4. Withdraw forces and retreat from occupied territories.

EU+UK (E):
1. Continue providing military aid to U.
2. Increase military involvement, potentially deploying ground troops.
3. Form a coalition to pressure R diplomatically and economically.
4. Negotiate with R for a ceasefire or peace agreement.

America (A):
1. Continue providing military aid to U.
2. Withhold military aid to pressure U into accepting a ceasefire.
3. Increase diplomatic efforts to broker a peace agreement.
4. Join E in forming a coalition to support U.

China (C):
1. Maintain neutrality and limited support.
2. Increase support to R.
3. Mediate between U and R to broker a peace agreement.
4. Increase diplomatic pressure on R to de-escalate the conflict.

Possible Outcomes and Payoffs

Outcome 1: The conflict continues as before.
- U: Continued suffering and economic strain, but maintains resistance.
- R: Ongoing military and economic costs, but consolidates occupied territories.

- E: Continued financial and military support costs, potential political strain.
- A: Continued financial and military support costs, potential political strain.
- C: Maintains neutrality, limited impact.

Outcome 2: E moves into U, limiting the conflict, resulting in a truce.
- U: Temporary relief and potential for rebuilding.
- R: Forced to negotiate, potential loss of occupied territories.
- E: Increased military involvement, potential political and economic costs.
- A: Potentially reduced involvement, diplomatic success.
- C: Maintains neutrality, potential diplomatic role.

Outcome 3: E moves into U, R is offended, and the conflict escalates.
- U: Increased suffering and destruction.
- R: Escalated military and economic costs, potential for broader conflict.
- E: Significant military and economic costs, potential political backlash.
- A: Increased pressure to intervene, potential political and economic costs.
- C: Increased diplomatic pressure, potential involvement.

Outcome 4: R backs down and retreats.
- U: Relief and potential for rebuilding, regains territories.
- R: Loss of occupied territories, potential political backlash.
- E: Diplomatic success, reduced military costs.
- A: Diplomatic success, reduced military costs.
- C: Maintains neutrality, potential diplomatic role.

Outcome 5: R and U ceasefire with R consolidating territories occupied.
- U: Loss of territories, potential for rebuilding.
- R: Consolidates gains, reduced military costs.
- E: Diplomatic success, reduced military costs.
- A: Diplomatic success, reduced military costs.
- C: Maintains neutrality, potential diplomatic role.

Payoff Summary

Outcome	Ukraine (U)	Russia (R)	EU+UK (E)	America (A)	China (C)
1	-2	-1	-1	-1	0
2	1	-1	-1	1	0
3	-3	-2	-2	-2	-1
4	2	-2	1	1	0
5	-1	1	1	1	0

Nash Equilibrium Analysis

A Nash Equilibrium occurs when no player can improve their payoff by unilaterally changing their strategy, given the strategies of the other players.

Equilibrium 1:

- Ukraine (U): Continue fighting with the current level of support from E and A.
- Russia (R): Continue the conflict and consolidate occupied territories.
- EU+UK (E): Continue providing military aid to U.
- America (A): Continue providing military aid to U.
- China (C): Maintain neutrality and limited support.

Outcome and Payoffs:

- U: -2
- R: -1
- E: -1
- A: -1
- C: 0

Equilibrium 2:

- Ukraine (U): Negotiate directly with R for a ceasefire or peace agreement.
- Russia (R): Agree to a ceasefire and negotiate terms with U.
- EU+UK (E): Negotiate with R for a ceasefire or peace agreement.
- America (A): Increase diplomatic efforts to broker a peace agreement.
- China (C): Mediate between U and R to broker a peace agreement.

Outcome and Payoffs:

- U: 1
- R: -1
- E: 1
- A: 1
- C: 0

Equilibrium 3:

- Ukraine (U): Accept a ceasefire without A's security guarantee.
- Russia (R): Agree to a ceasefire and negotiate terms with U.
- EU+UK (E): Negotiate with R for a ceasefire or peace agreement.
- America (A): Withhold military aid to pressure U into accepting a ceasefire.
- China (C): Maintain neutrality and limited support.

Outcome and Payoffs:

- U: -1
- R: 1
- E: 1
- A: 1
- C: 0

Payoff Summary for Nash Equilibria

Equilibrium	Ukraine (U)	Russia (R)	EU+UK (E)	America (A)	China (C)
1	-2	-1	-1	-1	0
2	1	-1	1	1	0
3	-1	1	1	1	0