

# Game-Theoretic Analysis of U.S.-China Economic Relations

Comprehensive User Guide & Technical Documentation

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## 1. Introduction & Overview

This application is a PhD-level interactive research tool designed to analyze the structural transformation of U.S.-China economic relations from 2001 to 2025 using rigorous game-theoretic frameworks. Unlike static reports, this application allows users to manipulate variables, run simulations, and visually explore the mathematical underpinnings of trade conflict.

### Key Objectives:

- Model the shift from cooperative 'Harmony' to conflictual 'Prisoner's Dilemma'.
- Quantify the impact of 'Vendor Financing' (Trade Deficit recycling) on Treasury yields.
- Empirically validate 'Tit-for-Tat' tariff strategies during the 2018-2025 Trade War.
- Provide dynamic visualizations of Nash Equilibria and Pareto Efficiency.

## 2. Navigation & User Interface

The application uses a Sidebar Navigation menu on the left side of the screen. The main sections are:

Section	Purpose	Key Features
Executive Summary	High-level Findings	Metric Cards, Key Correlations, Core Thesis
Strategic Analysis	Interactive Models	Payoff Matrices, 3D Plots, Phase Diagrams
Mathematical Proofs	Formal Logic	20+ Theorems, Derivations, Interactive Sliders
Advanced Simulations	Agent-Based Models	Tournament Arena, Evolutionary Lab
Methodology	Academic Basis	Data Sources, Assumptions, Citations
Research Documents	Library	Access to PDF Reports, User Guide

### 3. Core Functional Modules

#### 3.1 Strategic Analysis Module

This module visualizes the 2x2 Normal-Form Game between the U.S. and China.

##### Features:

- **Payoff Matrix Viewer:** Displays the 2x2 matrix (Cooperate/Defect) with updated payoff values based on the year selected.
- **Nash Equilibrium Solver:** Automatically highlights the Nash Equilibrium (NE) and checks for Dominant Strategies.
- **Pareto Efficiency Frontier:** Plots the payoffs to show if the NE is Pareto Efficient or if a better outcome exists (Prisoner's Dilemma).

#### 3.2 Mathematical Proofs Engine

Access formal derivations for over 20 theorems. Select a proof type from the sidebar dropdown.

Category	Examples
Nash Equilibrium	Existence, Uniqueness, Mixed Strategy
Dominant Strategies	Strict Dominance, Weak Dominance
Repeated Games	Folk Theorem, Grim Trigger, Tit-for-Tat
Economic/Empirical	Yield Suppression, Tariff Correlations

#### 3.3 Advanced Simulations Hub

**Tournament Arena:** Runs an Axelrod-style round-robin tournament. You can pit strategies like 'TitForTat', 'AlwaysDefect', and 'GrimTrigger' against each other.

**Evolutionary Lab:** Simulates a population of agents. Uses Replicator Dynamics to show how the population share of each strategy provides over generations. (*Tip: Cooperation survives only if the Discount Factor  $\delta$  is high enough.*)

## 4. Game Theory Concepts Primer

### *The Prisoner's Dilemma*

The core model of the 2018-2025 Trade War. Even though Mutual Cooperation (Free Trade) is globally optimal, Mutual Defection (Tariff War) is the unique Nash Equilibrium because each player has an incentive to defect.

	China Cooperate	China Defect
US Cooperate	Reward (3, 3) (Free Trade)	Sucker (0, 5) (US Surplus)
US Defect	Temptation (5, 0) (China Surplus)	Punishment (1, 1) (Trade War)

Fig 1: Standard Prisoner's Dilemma Payoff Matrix (Ordinal Payoffs)

### *Grim Trigger Strategy*

A strategy where a player cooperates until the opponent defects once, after which they defect forever. It supports cooperation in repeated games if players are patient (high discount factor).

## 5. Data Sources & Methodology

All data is sourced from reputable government and international institutions.

Variable	Source	Frequency
U.S. Trade Deficit	U.S. Census Bureau	Annual (2001-2025)
China FX Reserves	SAFE (State Admin of Foreign Exchange)	Annual
Treasury Yields (10Y)	FRED (Federal Reserve)	Daily/Annual Avg
GDP Growth	World Bank	Annual
Tariff Rates	Peterson Institute (PIIE)	Specific Events

## 6. Troubleshooting

- **Visualizations Blank:** Refresh the page. High interactive load can sometimes stall Plotly charts.
- **PDFs Not Opening:** Ensure your browser allows pop-ups or use the embedded viewer.