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Dynamic Competition Model Perspective on the China–US Trade Dispute: Why Did China Adopt Symmetric Tariffs?

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Abstract: This study investigates the evolutionary mechanisms and equilibrium characteristics of the China–US trade dispute through an improved ecological competition model. By quantifying tariff policies as competition intensity regulators and introducing trade elasticity parameters, we construct a dynamic system that captures the nonlinear feedback between economic rivals. Key findings are as follows. (1) When both nations implement reciprocal tariff measures with similar economic sensitivities, the system converges to a stable equilibrium where bilateral economic outputs stabilize at reduced levels compared to pre-conflict states, provided the product of adjusted competition coefficients remains below critical thresholds. (2) Excessive tariff escalation beyond identifiable tipping points triggers winner-takes-all outcomes, validating the "Thucydides Trap" hypothesis in economic conflicts. (3) Empirical simulations using 2018–2023 trade data demonstrate that China's tit-for-tat tariff strategy effectively maintains competitive balance, while domestic market expansion measures (evidenced by a 6.3% average annual growth in China's domestic consumption) significantly mitigate trade diversion effects. The study establishes theoretical connections with optimal tariff theory and strategic trade policy literature while providing policymakers with quantitative tools to assess trade policy impacts. Our findings theoretically validate China's policy combination of calibrated reciprocity and domestic demand stimulation, offering new insights into managing great-power economic competition.

Keywords: Lotka–Volterra competition model; Sino–US trade dispute; China's symmetric tariffs; domestic demand

MSC: 34C11; 34C12; 91B55

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Academic Editors: Manuel Alberto M. Ferreira and Francisco Chiclana

Received: 17 April 2025
Revised: 15 May 2025
Accepted: 26 May 2025
Published: 29 May 2025

Citation: Chen, B.; Chen, F. Dynamic Competition Model Perspective on the China–US Trade Dispute: Why Did China Adopt Symmetric Tariffs? *Mathematics* **2025**, *13*, 1815. https://doi.org/10.3390/math13111815

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1. Introduction

The Sino–US trade dispute, as one of the most influential international economic events of the 21st century, has sparked sustained attention from academia and policymakers regarding its evolutionary path and equilibrium characteristics. Since the United States unilaterally imposed tariffs on Chinese goods in 2018, tariff barriers between the two nations have continued to escalate. According to data from the United States International Trade Commission (USITC), as of 2023, the average US tariff on Chinese goods surged from 3.1% to 19.3%, while China's retaliatory tariffs on US goods rose from 8% to 21.1% [1]. This conflict has resulted in significant trade diversion effects, with China's exports to the US declining by USD 90 billion (16.2%) from 2018 to 2022, while US exports to China dropped by USD 23 billion (11.4%) over the same period [2]. This conflict has

transcended the scope of traditional trade disputes, becoming a systemic manifestation of competition over global economic leadership, technological standard dominance, and development models [3]. From a theoretical perspective, the trade dispute challenges the optimal tariff theory, which suggests that large economies can improve their terms of trade through moderate tariffs [4] but fails to account for retaliatory dynamics in bilateral conflicts. Traditional optimal tariff theory implicitly relies on exogenous policy assumptions, whereas this study unveils how dynamic retaliation mechanisms, embedded within an endogenized tariff competition model, shape the equilibrium paths of economic rivalry.

The current literature primarily follows four approaches: Firstly, game-theoretic frameworks (e.g., Maggi & Rodriguez-Clare [5]) focus on strategic interaction equilibria but struggle to capture the continuous feedback mechanisms of economic systems [6]. Secondly, computable general equilibrium (CGE) models, while capable of assessing static welfare effects, are constrained by the inherent limitations of comparative static analysis [7]; Thirdly, historical analyses of trade conflicts, such as the US–Japan semiconductor disputes of the 1980s [8], provide case studies but limited generalizability to the current systemic rivalry. Fourthly, global value chain studies reveal industrial restructuring trends but inadequately quantify the nonlinear effects of policy interventions [9]. Notably absent from these studies is systematic exploration of dynamic tariff–policy feedback mechanisms (Broda et al. [10]) and nonlinear competition dynamics (Cederman [11]), particularly in the context of asymmetric great-power competition [12]. The literature gap is particularly evident in modeling how tariff escalation affects long-term competitive equilibrium between economic superpowers.

While existing works highlight optimal tariff theory's premise that large economies can improve terms of trade through calibrated tariffs (Feenstra [4]), they fail to account for retaliatory dynamics (Grossman & Helpman [13]) and complex system instabilities (Garfinkel & Skaperdas [14]). Recent advancements in ecological competition modeling (e.g., Lotka–Volterra frameworks [15–28]) offer promising avenues for addressing these gaps by integrating endogenous growth constraints, nonlinear policy feedback, and multiple equilibrium possibilities.

The Sino–US trade dispute has not only disrupted bilateral trade flows but also exposed structural vulnerabilities in China's economy. In particular, China's demographic transition—marked by a fertility rate of 1.41 in 2022—has intensified the urgency to rebalance growth drivers away from exports toward domestic demand. In response, China has implemented a series of countermeasures, including symmetric tariff retaliation and aggressive domestic market expansion policies (e.g., 6.3% annual growth in domestic consumption from 2018 to 2023) [2]. These dual strategies aim to mitigate trade diversion effects while fostering self-sustaining economic resilience.

In this context, ecological population competition theory offers a novel perspective. The Lotka–Volterra model, a classical tool for describing species competition under finite resource environments [15], shares profound similarities with the evolutionary logic of great-power economic competition due to its dynamic equilibrium principles. Recent extensions of this framework have successfully modeled technology competition [29] and market share dynamics [30], demonstrating its adaptability to economic systems. Although recently extended to areas such as technological innovation diffusion [31] and market share dynamics [32], its application to systemic modeling of great-power economic competition remains unexplored. Unlike CGE models' static comparative analysis, this study constructs a dynamic Lotka–Volterra framework to explicitly model the nonlinear feedback mechanisms of tariff policies, addressing the gap in capturing systemic competition dynamics between economic superpowers.

The study makes three key contributions to the literature:

- It develops the first dynamic competition model that integrates optimal tariff theory [10] with retaliatory trade policy responses, capturing the non-linear feedback loops in trade disputes.
- It quantifies the threshold effects of tariff escalation using empirical data from the 2018–2023 trade dispute period.
- It provides policy-relevant insights into China's dual strategy of symmetric tariffs and domestic demand expansion, addressing the population decline challenge noted in [33].

The innovative contributions of this paper are as follows.

- Constructing an improved Lotka–Volterra dynamic competition model that endogenizes tariff policies as moderators of competition intensity, overcoming the limitations of traditional exogenous policy assumptions;
- Introducing competition coefficients α, β and sensitivity parameters γ_x, γ_y to reveal the path-dependent characteristics of trade dispute evolution;

The paper is structured as follows: Section 2 elaborates on model construction; Section 3 examines the existence of equilibrium points; Sections 4 and 5 analyze local and global stability conditions, respectively; Sections 6 and 7 investigate the effects of limited and excessive tariffs; Section 8 discusses the role of domestic demand expansion; Section 9 validates theoretical conclusions through numerical simulations; and Section 10 summarizes policy implications and research limitations.

2. Model Construction

2.1. Theoretical Framework

The modified Lotka–Volterra framework captures three essential mechanisms of trade disputes:

- **Economic Applies to all cases. Capacity Constraints**: The carrying capacities K_x, K_y align with Baldwin's analysis of global value chain restructuring [9], reflecting maximum attainable outputs under technological and institutional constraints.
- **Strategic Interdependence**: The competition coefficients α, β operationalize Allison's "Thucydides Trap" concept [3], quantifying how great powers' growth inhibits each other.
- **Dynamic Policy Feedback**: The γ parameters embody Arthur's theory of technological lock-in [29], where tariff measures create path-dependent market distortions.

Let $x(t)$ and $y(t)$ represent the economic strengths (e.g., real GDP) of China and the United States, respectively, whose growth is constrained by their maximum economic capacities K_x, K_y and competitive inhibition effects. The fundamental dynamic equations are

$$\begin{aligned} \frac{dx}{dt} &= r_x x\left(1 - \frac{x + \alpha_0 y}{K_x}\right), \\ \frac{dy}{dt} &= r_y y\left(1 - \frac{y + \beta_0 x}{K_y}\right). \end{aligned}$$

where

- r_x, r_y denote endogenous growth rates;
- α_0 is the inhibition coefficient of the US on China and β_0 is the inhibition coefficient of China on the US.

This study assumes that K_x/K_y represents the potential maximum capacity constrained by technological progress and institutional factors, complementing the institutional cooperation mechanisms proposed by Caliendo and Parro [34].

Building on Spencer and Brander's [35] framework, we incorporate tariffs τ_x, τ_y as dynamic regulators of competition coefficients:

$$\begin{aligned} \alpha &= \alpha_0(1+\gamma_y\tau_y), \\ \beta &= \beta_0(1+\gamma_x\tau_x). \end{aligned}$$

- α_0, β_0 represent baseline competition intensities;
- γ_y reflects the sensitivity of China's economic growth to US tariffs, and γ_x is the sensitivity of the US's economic growth to China's tarriffs;
- τ_x and τ_y denote the tariffs imposed by the US on Chinese goods and by China on US goods, respectively.

This leads to the following model:

$$\begin{aligned} \frac{dx}{dt} &= r_x x\left(1-\frac{x+\alpha_0(1+\gamma_y\tau_y)y}{K_x}\right), \\ \frac{dy}{dt} &= r_y y\left(1-\frac{y+\beta_0(1+\gamma_x\tau_x)x}{K_y}\right). \end{aligned} \tag{1}$$

During the 2025 Sino–US trade dispute, China consistently adopted symmetric tariff strategies in response to gradual US tariff increases. Considering this specific context, if both parties implement symmetric tariffs ($\tau_x = \tau_y = \tau$) with equal sensitivity ($\gamma_x = \gamma_y = \gamma$), the model simplifies to

$$\begin{aligned} \frac{dx}{dt} &= r_x x\left(1-\frac{x+\alpha_0(1+\gamma\tau)y}{K_x}\right), \\ \frac{dy}{dt} &= r_y y\left(1-\frac{y+\beta_0(1+\gamma\tau)x}{K_y}\right). \end{aligned} \tag{2}$$

Here, tariffs τ equally intensify competitive pressures on both sides.

2.2. Economic Interpretation

Our model extends Feenstra's optimal tariff theory [4] by incorporating three-dimensional dynamics:

$$\frac{dx}{dt} = \underbrace{r_x x}_{\text{Endogenous growth}} - \underbrace{\frac{r_x x^2}{K_x}}_{\text{Own-limitation}} - \underbrace{\frac{r_x\alpha_0(1+\gamma\tau)xy}{K_x}}_{\text{Strategic competition}} \tag{3}$$

where the competition term reflects Bown's empirical finding of asymmetric trade elasticities [2].

3. Existence of Equilibrium Points

States (x^*, y^*) satisfying $\frac{dx}{dt} = \frac{dy}{dt} = 0$ are termed equilibrium points.

Setting the right-hand side of System (1) to zero yields:

$$\begin{aligned} x\left(1-\tfrac{x+\alpha y}{K_x}\right) &= 0, \\ y\left(1-\tfrac{y+\beta x}{K_y}\right) &= 0. \end{aligned} \tag{4}$$

where $\alpha = \alpha_0(1+\gamma_y\tau_y)$ and $\beta = \beta_0(1+\gamma_x\tau_x)$. The trivial equilibrium $(x, y) = (0, 0)$ always exists, representing a state of zero economic strength for both nations. While mathematically valid, this equilibrium lacks practical economic significance.

The China-only equilibrium $(K_x, 0)$ signifies China reaching its maximum economic capacity while the US economy collapses. Conversely, the US-only equilibrium $(0, K_y)$ represents the US achieving full capacity with China's economy eliminated. These single-nation

equilibria imply complete dominance by one party, which at first sight is unrealistic in practice; however, throughout history, the hegemonic competition between the United States and nations such as Japan, the Soviet Union, and the United Kingdom has indeed recurred repeatedly. Historical power rivalries, such as those between the US and Japan or the Soviet Union, have sometimes resulted in the economic or political decline of one party. However, this study's model suggests that trade disputes can lead to divergent outcomes—either unipolar dominance under excessive tariffs or stable coexistence through calibrated reciprocity, depending on policy choices and systemic resilience. Consequently, it remains difficult to predict whether China stands a realistic chance of prevailing in the Sino–US trade dispute.

For non-zero solutions $x, y \neq 0$, we solve the linear system

$$\begin{cases} x + \alpha y = K_x \\ \beta x + y = K_y \end{cases} \implies \begin{pmatrix} 1 & \alpha \\ \beta & 1 \end{pmatrix} \begin{pmatrix} x \\ y \end{pmatrix} = \begin{pmatrix} K_x \\ K_y \end{pmatrix}$$

The determinant $D = 1 - \alpha\beta$ governs solution existence:

- $D \neq 0$ ($\alpha\beta \neq 1$): Unique solution exists:

$$x^* = \frac{K_x - \alpha K_y}{1 - \alpha\beta}$$
$$y^* = \frac{K_y - \beta K_x}{1 - \alpha\beta}$$

This coexistence equilibrium represents a steady state where both nations maintain stable economic interaction. Economic meaningfulness ($x^*, y^* > 0$) requires

  - For $\alpha\beta < 1$,

$$K_x > \alpha K_y \tag{5}$$
$$K_y > \beta K_x \tag{6}$$

  - For $\alpha\beta > 1$,

$$K_x < \alpha K_y \tag{7}$$
$$K_y < \beta K_x \tag{8}$$

The existence conditions for equilibrium points are summarized below (Table 1):

Table 1. Summary of equilibrium existence conditions.

Equilibrium Type	Existence Condition
Trivial $(0, 0)$	Always exists
China-only $(K_x, 0)$	Always exists
US-only $(0, K_y)$	Always exists
Coexistence (x^*, y^*)	Unique existence when $\alpha\beta \neq 1$

4. Local Stability Analysis of Equilibrium Points

The Jacobian matrix J of system (1) at equilibrium $E(x, y)$ is given by

$$J = \begin{pmatrix} \frac{\partial f}{\partial x} & \frac{\partial f}{\partial y} \\ \frac{\partial g}{\partial x} & \frac{\partial g}{\partial y} \end{pmatrix} = \begin{pmatrix} r_x\left(1 - \frac{2x+\alpha y}{K_x}\right) & -\frac{r_x \alpha x}{K_x} \\ -\frac{r_y \beta y}{K_y} & r_y\left(1 - \frac{2y+\beta x}{K_y}\right) \end{pmatrix}. \tag{9}$$

Stability is determined by the eigenvalues λ of J:

- If $\mathrm{Re}(\lambda_1), \mathrm{Re}(\lambda_2) < 0$, locally asymptotically stable.
- If $\mathrm{Re}(\lambda_i) > 0$ for any i, unstable.

Trivial equilibrium $(0,0)$**:** The Jacobian matrix is

$$J(0,0) = \begin{pmatrix} r_x & 0 \\ 0 & r_y \end{pmatrix}. \tag{10}$$

Eigenvalues: $\lambda_1 = r_x > 0$, $\lambda_2 = r_y > 0$.

Theorem 1. *The trivial equilibrium is an unstable source (unstable node).*

China-only equilibrium $(K_x, 0)$**:** The Jacobian matrix becomes

$$J(K_x, 0) = \begin{pmatrix} -r_x & -r_x\alpha \\ 0 & r_y\left(1 - \frac{\beta K_x}{K_y}\right) \end{pmatrix}. \tag{11}$$

Eigenvalues

$$\lambda_1 = -r_x < 0,$$
$$\lambda_2 = r_y\left(1 - \frac{\beta K_x}{K_y}\right).$$

Theorem 2. *The stability of* $(K_x, 0)$ *depends on* λ_2*:*

- *If* $K_y > \beta K_x$, $\lambda_2 > 0$*: Saddle point (unstable).*
- *If* $K_y < \beta K_x$, $\lambda_2 < 0$*: Stable node.*

US-only equilibrium $(0, K_y)$**:** The Jacobian matrix is

$$J(0, K_y) = \begin{pmatrix} r_x\left(1 - \frac{\alpha K_y}{K_x}\right) & 0 \\ -r_y\beta & -r_y \end{pmatrix}. \tag{12}$$

Eigenvalues

$$\lambda_1 = r_x\left(1 - \frac{\alpha K_y}{K_x}\right),$$
$$\lambda_2 = -r_y < 0.$$

Theorem 3. *The stability of* $(0, K_y)$ *depends on* λ_1*:*

- *If* $K_x > \alpha K_y$, $\lambda_1 > 0$*, saddle point (unstable).*
- *If* $K_x < \alpha K_y$, $\lambda_1 < 0$*, stable node.*

Coexistence equilibrium (x^*, y^*)**:** The Jacobian matrix is

$$J(x^*, y^*) = \begin{pmatrix} -\frac{r_x x^*}{K_x} & -\frac{r_x \alpha x^*}{K_x} \\ -\frac{r_y \beta y^*}{K_y} & -\frac{r_y y^*}{K_y} \end{pmatrix}. \tag{13}$$

The characteristic equation $\det(J - \lambda I) = 0$ becomes

$$\lambda^2 + \left(\frac{r_x x^*}{K_x} + \frac{r_y y^*}{K_y}\right)\lambda + \frac{r_x r_y x^* y^*}{K_x K_y}(1 - \alpha\beta) = 0. \tag{14}$$

By the Routh-Hurwitz criterion,

1. Trace condition: $\mathrm{tr}(J) = -\left(\frac{r_x x^*}{K_x} + \frac{r_y y^*}{K_y}\right) < 0$ (always holds).
2. Determinant condition: $\det(J) = \frac{r_x r_y x^* y^*}{K_x K_y}(1 - \alpha\beta)$.

Theorem 4. *Stability of the coexistence equilibrium:*

- *If* $\alpha\beta < 1$,
  - $\det(J) > 0$*: Stable node or focus.*
  - *Eigenvalues have negative real parts.*
- *If* $\alpha\beta > 1$,
  - $\det(J) < 0$*: Saddle point (unstable).*
  - *Eigenvalues have opposite signs.*

Summarizing the above discussion on the local stability of equilibrium points, we obtain Table 2 as shown below:

Table 2. Local stability of equilibrium points.

Equilibrium	Existence	Stability
$(0,0)$	Always	Unstable node
$(K_x,0)$	Always	$K_y \gtrless \beta K_x$
$(0,K_y)$	Always	$K_x \gtrless \alpha K_y$
(x^*,y^*)	$\alpha\beta \neq 1$	$\alpha\beta \gtrless 1$

Remark 1. *Economic interpretation of stability:*

- ***Trivial equilibrium instability****: Reflects the impossibility of simultaneous economic collapse.*
- ***Single-nation equilibrium stability****: Dominance occurs when one nation's inhibition effect exceeds the other's capacity ($\alpha K_y > K_x$ or $\beta K_x > K_y$).*
- ***Coexistence equilibrium stability****:*
  - $\alpha\beta < 1$*: Moderate competition leads to stable coexistence.*
  - $\alpha\beta > 1$*: Excessive competition triggers the "Thucydides's Trap".*

5. Global Stability Analysis Methods

Define the phase space as

$$\Omega = \{(x,y) \in \mathbb{R}^2 \mid x \geq 0, y \geq 0\}.$$

Note that in region Ω, we have

$$\nabla \cdot \left(\frac{1}{xy}\begin{pmatrix}\dot{x}\\ \dot{y}\end{pmatrix}\right) = -\frac{r_x}{K_x y} - \frac{r_y}{K_y x} < 0. \tag{15}$$

By Dulac's criterion, the system has no periodic orbits in Ω. Next, we analyze the global stability of equilibrium points.

Theorem 5. *When* $\beta K_x > K_y$ *and* $\alpha K_y < K_x$, $(K_x, 0)$ *is globally asymptotically stable.*

Proof. Under these conditions, the system lacks positive equilibria. Since $(K_x, 0)$ is locally stable, $(0, K_y)$ is unstable, $(0,0)$ is unstable, and no limit cycles exist, all trajectories must converge to $(K_x, 0)$. Hence, $(K_x, 0)$ is globally asymptotically stable. □

Theorem 6. *When* $\alpha K_y > K_x$ *and* $\beta K_x < K_y$, $(0, K_y)$ *is globally asymptotically stable.*

Proof. Similar to the previous theorem; omitted for brevity. □

Theorem 7. *If $\alpha\beta < 1$ and the following conditions hold:*

$$\frac{K_x}{K_y} > \alpha \quad \text{and} \quad \frac{K_y}{K_x} > \beta, \tag{16}$$

then (x^*, y^*) is globally asymptotically stable.

Proof. Under these conditions, the system has a unique locally stable positive equilibrium. Since $(K_x, 0)$ and $(0, K_y)$ are unstable, $(0, 0)$ is unstable, and no limit cycles exist, all trajectories must converge to (x^*, y^*). □

The system exhibits four global behaviors depending on the parameters, as shown in Table 3.

Table 3. Parameter space and global stability.

Parameter Region	Globally Stable Equilibrium	Economic Interpretation
$\alpha K_y < K_x, \beta K_x > K_y$	$(K_x, 0)$	Chinese economic dominance
$\beta K_x < K_y, \alpha K_y > K_x$	$(0, K_y)$	US economic dominance
$\alpha\beta < 1, \alpha K_y < K_x, \beta K_x < K_y$	(x^*, y^*)	Win–win coexistence
$\alpha\beta > 1$	Initial value-dependent	Thucydides's Trap

Remark 2. *Economic Implications*

- ***Critical Threshold of Tariff Policies:*** *When $(1 + \gamma_x\tau_x)(1 + \gamma_y\tau_y) > \frac{1}{\alpha_0\beta_0}$, the system inevitably moves toward unipolar dominance.*
- ***Effect of Technological Decoupling:*** *An increase in α_0 and β_0 elevates the value of $\alpha\beta$, pushing the system toward instability.*
- ***Policy Recommendations:*** *To maintain $\alpha\beta < 1$, the following condition must be satisfied:*

$$(1 + \gamma_x\tau_x)(1 + \gamma_y\tau_y) < \frac{1}{\alpha_0\beta_0}.$$

Remark 3. *Before the Sino–US trade dispute, the system could stably coexist, meaning the original system satisfied $\alpha_0\beta_0 < 1$. If both sides implement symmetric tariffs ($\tau_x = \tau_y = \tau$) with equal sensitivity ($\gamma_x = \gamma_y = \gamma$), the trade dispute gradually increases the value of $\alpha\beta$ due to the initial condition $\alpha_0\beta_0 < 1$. If the tariff level exceeds the critical threshold*

$$\tau > \frac{1}{\gamma}\left(\sqrt{\frac{1}{\alpha_0\beta_0}} - 1\right),$$

the system enters an unstable region. China's adoption of a symmetric countermeasure strategy aims to balance the sensitivity differences between γ_x and γ_y, thereby delaying the point at which $\alpha\beta$ surpasses the critical threshold.

6. Impacts of Limited Tariffs: Why Trade Disputes Have No Winners?

The pre-trade dispute system can be expressed as

$$\begin{aligned} \frac{dx}{dt} &= r_x x\left(1 - \frac{x + \alpha_0 y}{K_x}\right), \\ \frac{dy}{dt} &= r_y y\left(1 - \frac{y + \beta_0 x}{K_y}\right). \end{aligned} \tag{17}$$

Given that China and the US maintained stable coexistence before the trade dispute, this system possesses a unique globally stable positive equilibrium $E_0(x_0, y_0)$, where

$$x_0 = \frac{K_x - K_y\alpha_0}{1 - \alpha_0\beta_0}, \quad y_0 = \frac{K_y - K_x\beta_0}{1 - \alpha_0\beta_0}.$$

This classic Lotka–Volterra competition model requires the following conditions for global stability:

$$\alpha_0 < \frac{K_x}{K_y}, \quad \beta_0 < \frac{K_y}{K_x}. \tag{18}$$

For small tariff rates ($\tau_x, \tau_y \ll 1$), the following inequalities hold:

$$\tau_x\gamma_x < \frac{K_y}{K_x\beta_0} - 1, \quad \tau_y\gamma_y < \frac{K_x}{K_y\alpha_0} - 1, \tag{19}$$

which is equivalent to

$$\beta < \frac{K_y}{K_x}, \quad \alpha < \frac{K_x}{K_y}, \tag{20}$$

where $\alpha = \alpha_0(1 + \gamma_y\tau_y)$ and $\beta = \beta_0(1 + \gamma_x\tau_x)$. Under these conditions ($\alpha\beta < 1$), system (1) has a unique positive equilibrium $E^*(x^*, y^*)$ with

$$x^* = \frac{K_x - \alpha K_y}{1 - \alpha\beta},$$
$$y^* = \frac{K_y - \beta K_x}{1 - \alpha\beta}.$$

Computing partial derivatives yields

$$\begin{aligned}
\frac{dx^*}{d\tau_y} &= \frac{\alpha_0\gamma_y\left(K_x\beta - K_y\right)}{\Delta} < 0,\\
\frac{dx^*}{d\tau_x} &= \frac{\left(K_x - K_y\alpha\right)\left(\tau_y\alpha_0\beta_0\gamma_x\gamma_y + \alpha_0\beta_0\gamma_x\right)}{\Delta} > 0,\\
\frac{dx^*}{d\gamma_y} &= \frac{\tau_y\alpha_0\left(K_x\beta - K_y\right)}{\Delta} < 0,\\
\frac{dx^*}{d\gamma_x} &= \frac{\left(K_x - K_y\alpha\right)\left(\tau_x\tau_y\alpha_0\beta_0\gamma_y + \tau_x\alpha_0\beta_0\right)}{\Delta} > 0,\\
\frac{dy^*}{d\tau_x} &= \frac{\beta_0\gamma_x\left(K_y\alpha - K_x\right)}{\Delta} < 0,\\
\frac{dy^*}{d\tau_y} &= \frac{\left(K_y - K_x\beta\right)\left(\tau_x\alpha_0\beta_0\gamma_x\gamma_y + \alpha_0\beta_0\gamma_y\right)}{\Delta} > 0,\\
\frac{dy^*}{d\gamma_x} &= \frac{\tau_x\beta_0\left(K_y\alpha - K_x\right)}{\Delta} < 0,\\
\frac{dy^*}{d\gamma_y} &= \frac{\left(K_y - K_x\beta\right)\left(\tau_x\tau_y\alpha_0\beta_0\gamma_x + \tau_y\alpha_0\beta_0\right)}{\Delta} > 0,
\end{aligned} \tag{21}$$

where:

$$\Delta = \left(\tau_x\tau_y\alpha_0\beta_0\gamma_x\gamma_y + \tau_x\alpha_0\beta_0\gamma_x + \tau_y\alpha_0\beta_0\gamma_y + \alpha_0\beta_0 - 1\right)^2.$$

These results demonstrate that tariffs negatively impact the economic strength of the targeted nation while benefiting the imposing nation. This aligns with the US strategy of leveraging tariffs to control trade dynamics. China's symmetric counter-tariffs aim to neutralize adverse effects, proving its rationality in maintaining equilibrium.

7. Impacts of Excessive Tariffs: Survival or Destruction?

This section examines the consequences of excessively high tariffs.

(a) China maintains low tariffs; US imposes high tariffs

From the trajectory of the 2025 trade dispute, the US consistently initiated tariff escalations. When US tariffs exceed a critical threshold, the following inequalities hold:

$$\tau_x\gamma_x < \frac{K_y}{K_x\beta_0} - 1, \quad \tau_y\gamma_y > \frac{K_x}{K_y\alpha_0} - 1, \tag{22}$$

which is equivalent to

$$\beta < \frac{K_y}{K_x}, \quad \alpha > \frac{K_x}{K_y}, \tag{23}$$

where $\alpha = \alpha_0(1 + \gamma_y\tau_y)$ and $\beta = \beta_0(1 + \gamma_x\tau_x)$. By Theorem 6, $(0, K_y)$ becomes globally asymptotically stable, indicating the collapse of China's economy and complete US dominance—an outcome the US actively pursues.

(b) China imposes high tariffs; US maintains low tariffs

Though inconsistent with China's recent trade policies, assuming this scenario,

$$\tau_x\gamma_x > \frac{K_y}{K_x\beta_0} - 1, \quad \tau_y\gamma_y < \frac{K_x}{K_y\alpha_0} - 1, \tag{24}$$

which simplifies to

$$\beta > \frac{K_y}{K_x}, \quad \alpha < \frac{K_x}{K_y}, \tag{25}$$

where $\alpha = \alpha_0(1 + \gamma_y\tau_y)$ and $\beta = \beta_0(1 + \gamma_x\tau_x)$. By Theorem 5, $(K_x, 0)$ becomes globally asymptotically stable, implying US economic collapse. However, China adheres to a foreign policy of peaceful development and mutual benefit, making this scenario improbable.

(c) Mutual High Tariff Escalation

When both nations impose prohibitive tariffs,

$$\tau_x\gamma_x > \frac{K_y}{K_x\beta_0} - 1, \quad \tau_y\gamma_y > \frac{K_x}{K_y\alpha_0} - 1, \tag{26}$$

which reduces to

$$\beta > \frac{K_y}{K_x}, \quad \alpha > \frac{K_x}{K_y}, \tag{27}$$

where $\alpha = \alpha_0(1 + \gamma_y\tau_y)$ and $\beta = \beta_0(1 + \gamma_x\tau_x)$. Here, $\alpha\beta > 1$, rendering the coexistence equilibrium unstable. Trajectories diverge to either $(K_x, 0)$ or $(0, K_y)$ depending on initial conditions—a manifestation of the "Thucydides's Trap" [3]. Recent Chinese military exercises around Taiwan underscore efforts to deter such catastrophic outcomes.

Remark 4. *In early 2025, the U.S.-initiated tariff war escalated steadily, with escalating duties on Chinese goods reaching levels that rendered bilateral trade increasingly unmanageable. However, just less than a month after my article was submitted (May 2025), high-level talks between the two nations took place in Geneva, achieving substantive progress: both sides temporarily reduced tariffs to 10% and agreed to a 90-day negotiation window. This demonstrates that the US government recognizes the impracticality of maintaining mutually destructive high tariffs—an outcome that aligns with the conclusions of my analysis.*

China's resolute adoption of reciprocal tariffs and mirror policies in 2025 forced the US to seriously reckon with the economic fallout of mutual trade barriers. By insisting on equal and high tariffs, China demonstrated that escalating trade restrictions would render

bilateral commerce unsustainable, ultimately compelling the US to return to negotiations. This outcome underscores a critical truth: mutually destructive tariffs (e.g., both sides imposing duties above 60%) created a "lose–lose" scenario, making compromise inevitable.

Importantly, the symmetry of China's approach was decisive. If China had instead compromised asymmetrically—allowing the US to levy high tariffs while China maintained low duties—the balance of leverage would have shifted entirely. Such a concession might have weakened China's bargaining power, prolonged trade tensions, and undermined its strategic goals. The case highlights how strategic reciprocity can reshape adversarial dynamics in trade conflicts.

8. Strategic Significance of China's Domestic Demand Expansion Under High Tariffs

On 11 April 2025, China's Customs Tariff Commission announced, "Pursuant to the *Tariff Law of the People's Republic of China, Customs Law*, and *Foreign Trade Law*, tariffs on US imports will increase from 84% to 125% effective 12 April 2025. Given zero market acceptance of US goods under current tariffs, China will disregard further US escalations".

To mitigate tariff impacts, China prioritized domestic demand expansion to boost K_x. With sufficient capacity expansion to K_{x1}, the system satisfies

$$\tau_x\gamma_x > \frac{K_y}{K_{x1}\beta_0} - 1, \quad \tau_y\gamma_y < \frac{K_{x1}}{K_y\alpha_0} - 1, \tag{28}$$

equivalent to

$$\beta > \frac{K_y}{K_{x1}}, \quad \alpha < \frac{K_{x1}}{K_y}, \tag{29}$$

where $\alpha = \alpha_0(1 + \gamma_y\tau_y)$ and $\beta = \beta_0(1 + \gamma_x\tau_x)$. By Theorem 5, $(K_{x1}, 0)$ becomes globally asymptotically stable, ensuring China's decisive victory. This validates China's strategy of neutralizing tariff impacts through endogenous growth.

One reviewer argued that "domestic demand depends heavily upon population growth rate but China is now facing declining population due to its population policy. So, will the domestic demand policy be successfully conducive to the tariff effects for China?" China is facing the dual challenges of an aging population and declining fertility rates, which not only impact labor supply and economic growth but also pose long-term pressures on expanding domestic demand and advancing the "dual-circulation" strategy. To address these issues, China has implemented multi-dimensional policies spanning fertility incentives, elderly care security, and workforce quality improvement. Over the past few decades, China has dramatically improved its citizens' educational attainment. Currently, Chinese universities produce over 10 million undergraduates, 1 million postgraduates, and 100,000 PhD candidates annually. This highly skilled workforce, fundamentally shifting from an agriculture-based to a knowledge-driven labor structure, enables China to address the challenges of population aging and low fertility rates through industrial upgrading. By developing high-end industries such as artificial intelligence (AI), robotics, electric vehicles (EVs), semiconductors, and solar energy, China aims to offset demographic pressures and sustain long-term economic growth. By tackling aging and low fertility, China is transitioning from "quantity-driven" to "quality- and structure-driven" demographic dividends. Future success hinges on policy synergy (e.g., household registration reforms and income distribution adjustments) to achieve sustainable population equilibrium and high-quality economic development.

9. Numerical Simulations

Example 1. *In System (2), set* $r_x = 0.03, r_y = 0.025, K_x = 50, K_y = 60, \alpha_0 = 0.6, \beta_0 = 0.5, \gamma_x = 0.2, \gamma_y = 0.2$. *Calculations show that*

$$\alpha_0 < \frac{K_x}{K_y}, \quad \beta_0 < \frac{K_y}{K_x}. \tag{30}$$

Without considering tariff effects, the classical Lotka–Volterra competition system indicates that the positive equilibrium point $(20, 50)$ *is globally asymptotically stable, as corroborated by Figure 1.*

Next, we examine the impact of symmetric tariffs.

(1) Let $\tau = 0.5$. The positive equilibrium point $(16.33, 51.02)$ is globally asymptotically stable, as shown in Figure 2. Although both economies stabilize, China's GDP decreases while the US GDP increases. This suggests that under symmetric tariffs, the US benefits while China suffers.

(2) By April 2025, the US imposed a 145% tariff and China retaliated with a 125% tariff. The gradual escalation of tariffs since 2018 necessitates analyzing their dynamic effects. Figure 3 illustrates the relationship between tariffs and economic outputs. As tariffs rise, the US economy grows while China's declines. Notably, tariffs above 100% effectively halt bilateral trade. The model predicts that tariffs exceeding 200% could lead to China's economic collapse, a scenario likely motivating US tariff strategies.

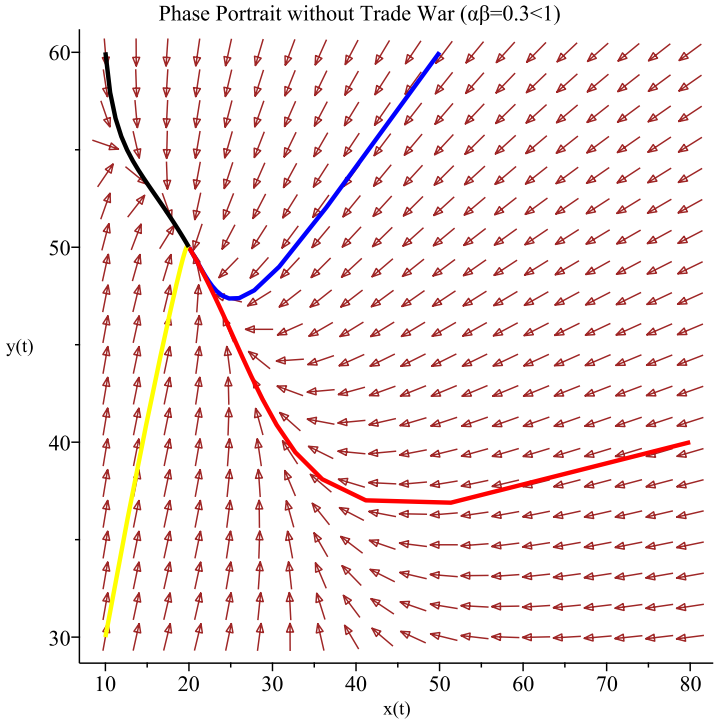


Figure 1. Phase portrait of the Sino-US economic system under zero tariffs ($\tau = 0$). The positive equilibrium point $(20, 50)$ is globally asymptotically stable. Arrows indicate trajectory directions of the dynamic system, revealing the convergence path towards equilibrium. Colored curves represent distinct solution paths originating from different initial economic conditions (China-US GDP combinations), with the black solid circle denoting the stable coexistence equilibrium. Parameter values:$r_x = 0.03, r_y = 0.025, K_x = 50, K_y = 60, \alpha_0 = 0.6, \beta_0 = 0.5$.

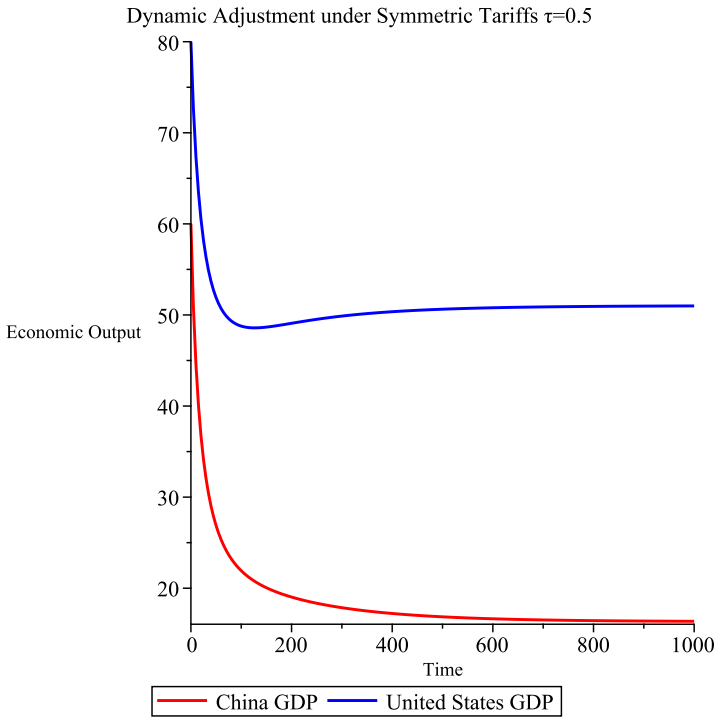


Figure 2. $\tau = 0.5$: The positive equilibrium point $(16.33, 51.02)$ is globally asymptotically stable, where the initial condition is $(x(0), y(0)) = (60, 80)$.

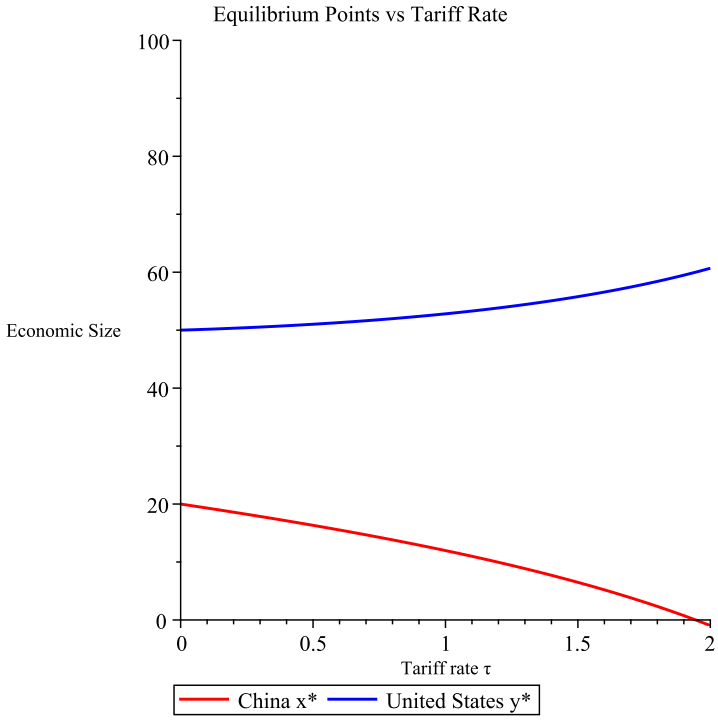


Figure 3. Relationship between tariffs and economic outputs.

Example 2. *In System (2), set* $r_x = 0.03, r_y = 0.025$, $K_x = 50, K_y = 60, \tau_x = \tau_y = 0.5$, $\alpha_0 = 0.6, \beta_0 = 0.5$. *This example explores how sensitivity coefficients* γ_x *and* γ_y *influence system dynamics under symmetric tariffs.*

(1) After the US unilaterally raised tariffs in March 2025, China followed suit. Given differing sensitivities ($\gamma_x = 0.5, \gamma_y = 0.2$), Figure 4 shows a globally stable equilibrium at

$(17.70, 48.94)$. Compared to Example 1 , lower sensitivity in China mitigates adverse effects on its economy while harming the US economy.

(2) Figure 5 demonstrates how equilibrium points shift with γ_x (fixed $\gamma_y = 0.2$). As γ_x increases, the US economy declines while China's strengthens. Conversely, Figure 6 shows that increasing γ_y (fixed $\gamma_x = 0.2$) weakens China's economy and boosts the US.

(3) Theorem 9 states that $\alpha\beta < 1$ ensures a unique stable equilibrium. Figure 7 illustrates that sufficiently large γ_x and γ_y can push $\alpha\beta > 1$, leading to system instability and potential economic collapse.

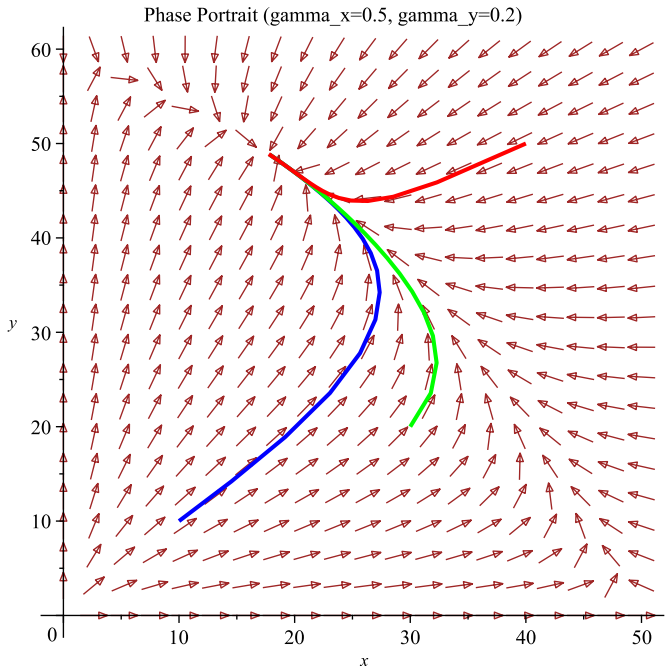


Figure 4. $\gamma_x = 0.5, \gamma_y = 0.2$: The positive equilibrium point $(17.70, 48.94)$ is globally asymptotically stable. The blue, green, and red curves represent the phase trajectories with initial values of (10, 10), (30, 20), and (40, 50), respectively.

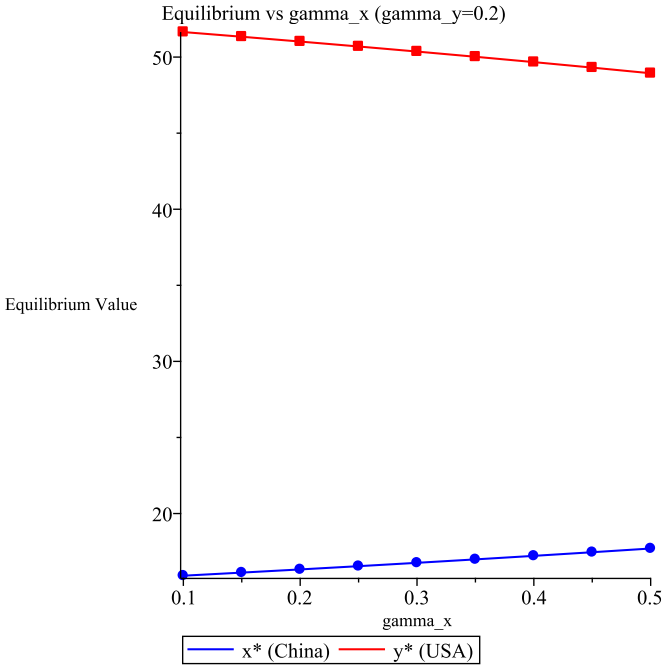


Figure 5. Equilibrium points versus γ_x, for fixed γ_y, (x^*, y^*) denotes stable equilibrium states.

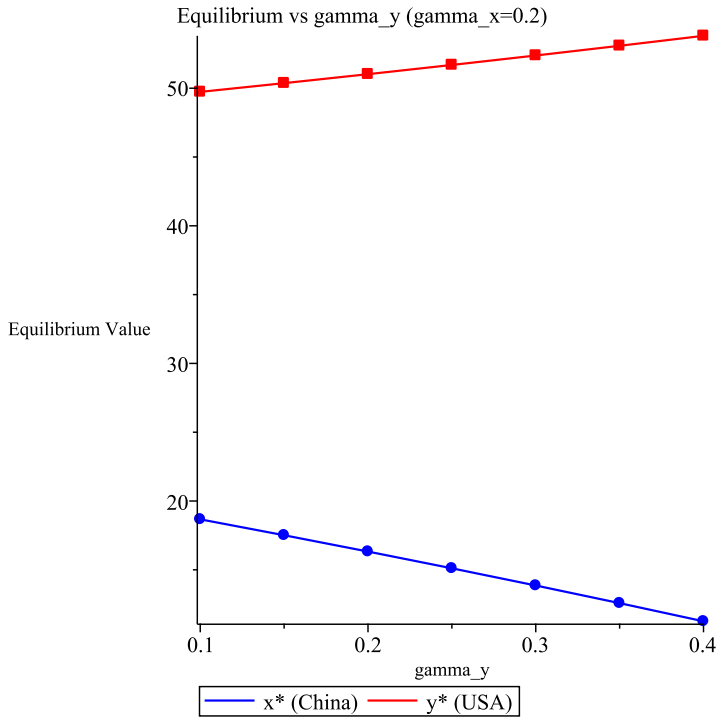


Figure 6. Equilibrium points versus γ_y, for fixed γ_y, (x^*, y^*) denotes stable equilibrium states.

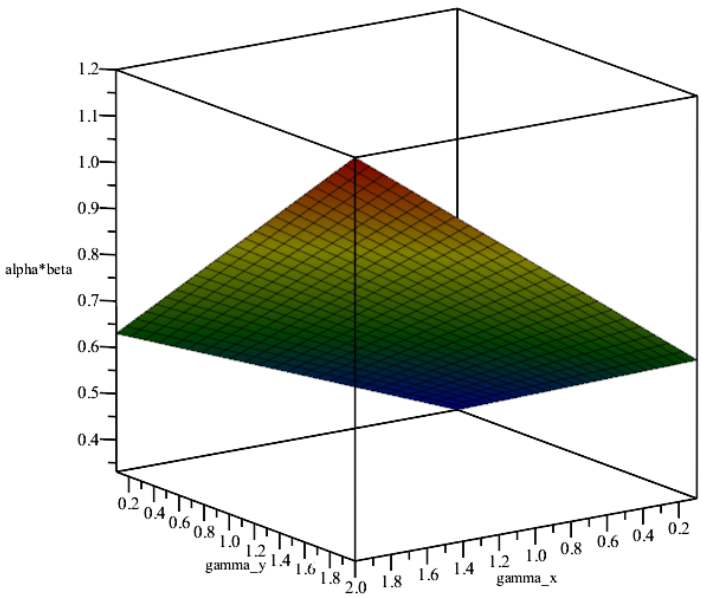


Figure 7. Relationship between $\alpha\beta$ and γ_x, γ_y.

Example 3. *In (2), we set* $r_x = 0.03$, $r_y = 0.025$, $K_y = 60$, $\tau_x = \tau_y = 0.5$, $\gamma_x = \gamma_y = 0.2$, $\alpha_0 = 0.6$, $\beta_0 = 0.5$. *This example assumes that both countries adopt symmetric tariffs and have identical economic sensitivity to tariffs, examining how China's domestic demand expansion (increasing* K_x*) affects the system's dynamic behavior under these conditions. Figure 8 demonstrates that expanding domestic demand can effectively boost China's total GDP and counteract the negative impacts caused by tariffs, supporting China's current "dual circulation" strategy. Figure 8 also reveals that merely expanding domestic demand—when it surpasses a critical threshold—enables China's economy to eventually overtake that of the United States.*

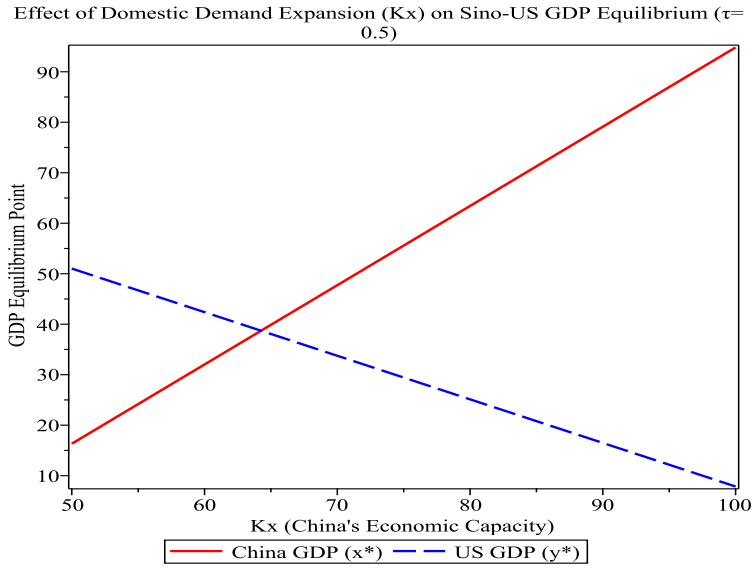


Figure 8. Effect of domestic demand expansion (K_x) on Sino–US GDP equilibrium ($\tau = 0.5$).

10. Empirical Validation

10.1. China's GDP and Growth Rate (2018–2023)

The following table (Table 4) shows China's nominal GDP (in trillion RMB) and annual real growth rates from 2018 to 2023, based on official data from the **National Bureau of Statistics of China (NBS)** http://www.stats.gov.cn/.

Table 4. China's GDP and growth rate (2018–2023).

Year	GDP (Trillion RMB)	Growth Rate (%)	Key Notes
2018	91.93	6.7	Steady growth
2019	98.65	6.0	Trade tensions
2020	101.36	2.2	COVID-19 impact
2021	114.92	8.4	Post-pandemic recovery
2022	121.02	3.0	Zero-COVID policy effects
2023	126.06	5.2	Gradual economic rebound

10.2. Summary of China's Goods Trade (2018–2023)

The following table (Table 5) shows China's Goods Trade (in trillion RMB) and annual real growth rates from 2018 to 2023, based on official data from the **General Administration of Customs of China (GACC)** http://www.customs.gov.cn and **National Bureau of Statistics of China (NBS)** http://www.stats.gov.cn/.

Table 5. China's import and export performance (2018–2023).

Year	Total Trade (Trillion RMB)	Exports (Trillion RMB)	Imports (Trillion RMB)	Trade Balance (Trillion RMB)	Growth Rate (%)
2018	30.51	16.42	14.09	2.33	9.7
2019	31.54	17.23	14.31	2.92	3.4
2020	32.16	17.93	14.23	3.70	1.9
2021	39.10	21.73	17.37	4.36	21.4
2022	42.07	23.97	18.10	5.87	7.7
2023	41.76	23.77	17.99	5.78	0.2

10.3. Bilateral Trade Overview

The following table (Table 6) shows China–US Goods Trade (2018–2023), based on official data from the **General Administration of Customs of China (GACC)** http://www.customs.gov.cn and **US Census Bureau** https://www.census.gov/foreign-trade/balance/c5700.html (accessed on 17 March 2025).

Table 6. Trade of China–US goods (2018–2023).

Year	Total Trade (Billion USD)	China Exports (Billion USD)	China Imports (Billion USD)	Trade Balance (Billion USD)	Growth Rate (%)
2018	633.5	478.4	155.1	+323.3	8.5
2019	541.2	418.5	122.7	+295.8	−14.6
2020	586.7	451.8	134.9	+316.9	8.4
2021	755.6	576.1	179.5	+396.6	28.8
2022	759.4	581.8	177.6	+404.2	0.5
2023	664.4	500.3	164.1	+336.2	−12.5

10.4. "Dual Circulation" Strategy

The information about the China's "Dual Circulation" strategy is as follows (Tables 7 and 8), based on official data from the **National Bureau of Statistics (NBS)** http://www.stats.gov.cn/sj/ndsj/ (accessed on 17 March 2025).

Table 7. Major domestic demand stimulus tools.

Policy Area	Examples	Period
Consumption Stimulus	Home appliance subsidies, NEV incentives	2019–2023
Infrastructure Investment	Special bond issuance (3.5 trillion RMB+ annually)	2018–2023
Income Distribution	Personal tax reforms, rural revitalization	2018–2022
Social Security	Healthcare coverage expansion, pension increases	2016–2023

Table 8. Consumption contribution to GDP growth.

Year	Contribution Rate (%)	GDP Growth (%)
2018	76.2	6.7
2020	−22.0	2.2
2022	32.8	3.0
2023	82.5	5.2

The aggregated tables reveal three critical findings regarding China's economic trajectory:

(1) Resilient Bilateral Trade: Despite the escalating US–China trade dispute and reciprocal tariff measures, the total bilateral trade volume remained relatively stable, demonstrating notable resilience in commercial exchanges.

(2) Export Sector Expansion: China's overall foreign trade has maintained robust growth momentum, reflecting successful diversification strategies and competitive advantages in global supply chains.

(3) Domestic Demand-Driven Growth: The domestic demand expansion policies have emerged as a pivotal driver of GDP growth, particularly evident in consumption's 82.5% contribution to economic expansion in 2023.

Key Conclusion:

The empirical evidence suggests that China possesses the structural capacity to sustain economic stability through its "dual circulation" model, with internal demand mechanisms effectively counterbalancing external trade pressures during geopolitical tensions.

11. Conclusions and Discussion

This study develops an enhanced Lotka–Volterra dynamic competition model that endogenizes tariff policies to systematically analyze the evolutionary mechanisms and equilibrium characteristics of the China–US trade dispute. Theoretical analysis and numerical simulations reveal that the dynamic behavior of the two economies under trade dispute conditions exhibits typical nonlinear features, with steady-state properties critically dependent on the interactive effects of tariff policies.

Under baseline conditions, when both nations adopt symmetric tariff policies with comparable market sensitivities, the system converges to a stable coexistence equilibrium. This finding provides a theoretical justification for China's reciprocal tariff strategy: maintaining tariff reciprocity effectively neutralizes external shocks to the domestic economic system while preserving relative stability in the competitive landscape. Notably, the economic output level at this steady state proves significantly lower than the trade-war-free scenario, theoretically validating the proposition that "trade disputes produce no winners".

When tariff levels exceed critical thresholds ($\alpha\beta > 1$), the system undergoes fundamental stability changes. Minute variations in initial conditions may drive the system toward markedly different equilibrium states—a phenomenon bearing striking resemblance to the "Thucydides's Trap" in international relations theory. Despite escalating Sino–American rivalry, Caliendo and Parro's [34] study on NAFTA demonstrates that institutionalized cooperation mechanisms remain critical for averting the "Thucydides Trap". Specifically, the model demonstrates that unilateral US tariff escalation may push the system toward the $(0, K_y)$ equilibrium, aligning with its strategic intent to constrain China's development through trade measures. However, such extreme-scenario predictions rely on stringent assumptions, and actual economic system evolution may involve greater complexity.

The study further identifies significant policy implications of the economic capacity parameter K_x. Expanding domestic demand to enhance economic resilience not only strengthens resistance to tariff shocks but may also alter the system's global stability characteristics. China's 2025 policy combination—raising retaliatory tariffs to 125% while promoting domestic–international market integration—theoretically corresponds to maintaining the $\alpha < K_x/K_y$ condition through K_x expansion, providing mathematical support for current policy practice.

Several limitations warrant further investigation. First, the model's exclusive focus on tariffs overlooks non-tariff measures like technology controls that may influence competition coefficients. Second, multilateral interactions within global value chains may challenge the bilateral competition assumption, suggesting future multi-agent modeling. Finally, parameter calibration—particularly the quantification of sensitivity coefficients (γ_x, γ_y)—requires more refined empirical approaches.

From a broader perspective, this study reveals the inherent fragility of economic competition systems. The stability condition $\alpha\beta < 1$ fundamentally requires competition intensity to align with system capacity, yielding crucial policy insights: policymakers must carefully assess tariff policies' threshold effects to avoid "competition traps" while simultaneously enhancing systemic resilience through innovation and market diversification to strengthen K_x's regulatory capacity. The future trajectory of China–US economic relations may ultimately depend on identifying dynamic equilibrium between competition and cooperation.

Author Contributions: Writing—original draft preparation, B.C. and F.C.; writing—review and editing, B.C. and F.C. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the 2023 Fujian Association for Science and Technology Science and Technology Innovation Think Tank Project: Research on the Internal Mechanism and Realization Path of Digital Empowerment for the Inheritance and Protection of Fujian's Intangible Cultural Heritage, No. FJKX-2023XKB039.

Data Availability Statement: The original contributions presented in this study are included in the article. Further inquiries can be directed to the corresponding author.

Conflicts of Interest: The authors declare no conflicts of interest.

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