International Journal of Environmental Sciences
ISSN: 2229-7359
Vol. 11 No. 22s, 2025
https://www.theaspd.com/ijes.php

US-China Economic Dynamics: Trade Balance And Technological Advancements

Hussain
Founder of Zahen India, Indore, India. Mail ID: husain.ali18@yahoo.com

Abstract
This paper examines the evolving economic rela- tionship between the United States and China, focusing on two critical aspects: the persistent trade imbalance and China's technological advancements. Analysis of the US-China trade balance from 2000 to 2023 reveals a steadily growing deficit, influenced by structural dependencies, policy interventions, and seasonal trends. Notable disruptions, such as the US-China trade war and the COVID-19 pandemic, had limited long- term impact on the deficit, underscoring the US's reliance on Chinese imports. In parallel, China's strategic investments in emerging technologies, including artificial intelligence, 5G, and blockchain, have positioned it as a global leader in innovation. Insights derived from web scraping, sentiment analysis, and R&D spending data reveal a sharp rise in mentions of key technologies since 2018, predominantly positive sentiment in technology discourse, and a narrowing gap in R&D spending between China and the US. Projections suggest China may surpass the US in R&D spending by 2035. These findings under- score the complexity of US-China economic interdependence, highlighting vulnerabilities in the US supply chain and the implications of China's technological ascent on global economic competitiveness.

I. INTRODUCTION

Over the past few decades, China's extraordinary economic transformation has fundamentally reshaped global trade, sup- ply chains, and the geopolitical landscape. From its origins as a predominantly agrarian, developing nation, China has evolved into a formidable global economic powerhouse, commanding significant influence across diverse international markets. This unprecedented trajectory of growth has positioned China as both a key trading partner and a strategic competitor to the United States, triggering ongoing debates regarding the nature, extent, and implications of China's economic rise on US interests.

The bilateral relationship between the United States and China is uniquely complex, characterized by deep economic interdependence alongside intensifying competition. As the world's two largest economies, the United States and China collectively shape global commerce, technology development, and financial stability. However, this interdependence is accompanied by mounting concerns over asymmetric depen- dencies, trade imbalances, and vulnerabilities within critical sectors of the US economy.

One of the most pressing concerns arises from China's expanding role as a dominant global supplier of manufactured goods, raw materials, and high-value components. The United States has become increasingly reliant on Chinese imports spanning strategic industries such as electronics, telecommunications, pharmaceuticals, consumer goods, and rare earth elements—materials essential for advanced technologies and defense applications. This dependence has exposed structural weaknesses within US supply chains, elevating risks to economic stability, national security, and domestic employment, particularly in manufacturing sectors that have experienced long-term decline.

Beyond trade, China's state-backed investments in tech- nological innovation have become a focal point of geopolitical competition. With robust national strategies such as "Made in China 2025" and aggressive investments in frontier domains including artificial intelligence, 5G telecommunica- tions, quantum computing, semiconductors, and biotechnology, China has demonstrated its ambition to achieve technological self-sufficiency and global leadership. This strategic pursuit is supported by substantial government funding for research and development (RD), workforce development ini- tiatives, and policies designed to nurture domestic champions capable of challenging US dominance in critical high-tech industries.

The intersection of economic dependency and technological rivalry raises important questions regarding the evolving power dynamics between the United States and China. While trade has delivered mutual benefits in terms of growth, effi- ciency, and consumer access to affordable goods, it has also deepened structural dependencies that could constrain US economic resilience. Simultaneously, China's rapid progress in emerging technologies threatens to erode longstanding US competitive advantages, with profound implications for innovation ecosystems, national security, and global standards setting.

Against this backdrop, the present study undertakes a comprehensive analysis of how China's economic ascent

influences the US economy, with a particular focus on trade patterns, supply chain vulnerabilities, and the technological landscape. By systematically examining recent trends in bilateral trade, investment flows, RD expenditures, and tech- nological discourse, this research aims to quantify the degree of economic exposure, assess the competitive positioning of both nations, and identify sectors where China's influence presents the most significant risks or strategic challenges to US interests.

In doing so, this work seeks to address the central research question: To what extent does China's economic rise constitute a threat to the United States, and in which specific domains—such as trade, technology, or supply chain integrity—are these threats most evident? Through this exam- ination, we aim to provide data-driven insights that contribute to the broader discourse on economic security, technological competitiveness, and policy responses necessary to safeguard US strategic interests in an era of intensifying US-China economic rivalry.

II. ECONOMIC GROWTH COMPARISON: CHINA VS. THE UNITED STATES

To evaluate the economic impact of China's growth relative to the United States, we conducted a comparative analysis of GDP trends for both countries from 2000 to 2023. This anal- ysis provides insights into the contrasting growth trajectories of these two major economies and highlights China's rapid economic ascent in recent decades, which raises questions about potential shifts in global economic influence.

A. Data Collection and Processing

We obtained annual GDP data for China and the United States using the World Bank API (wbgapi), specifically accessing the indicator NY.GDP.MKTP.CD, which represents GDP in current USD [?]. The data, retrieved in JSON format, was then parsed and structured into tables for further analysis and visualization. The use of standardized World Bank data ensures consistent, high-quality comparisons across years for both countries.

B. Calculating Growth Rates

To gain insights into growth patterns, we calculated the year-over-year GDP growth rates for each country. The growth rate was determined as the percentage change from the previous year's GDP, providing a standardized metric for economic expansion. Figures 1 and 2 illustrate these GDP values and growth rates, respectively, showing both the scale of economic output and the fluctuations in growth.

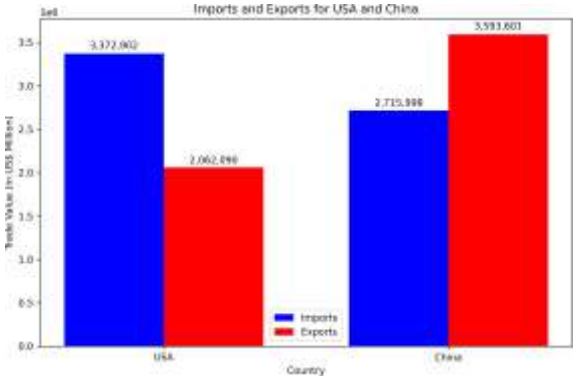

Fig. 1. Annual GDP of China and the United States (2000-2023)

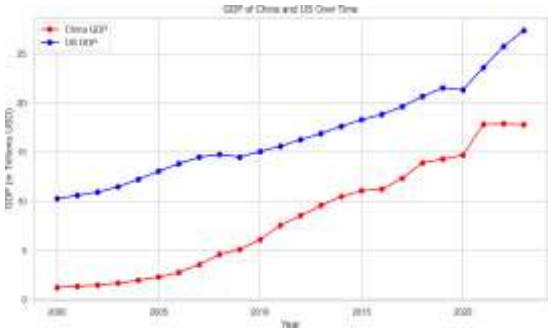

Fig. 2. Year-over-Year GDP Growth Rates of China and the United States (2000-2023)

C. Insights from the Data

As shown in Figure 1, the line plot contrasts the economic scales of China and the United States over time. Although the United States maintains a higher absolute GDP, China's GDP trajectory exhibits a steep incline, indicating a rapidly closing gap, particularly in the past decade. This trend is further emphasized in Figure 2, which illustrates the year- over-year growth rates. Here, China's high growth rates, although sometimes volatile, consistently surpass those of the United States. These fluctuations in China's growth reflect various factors,

including periods of economic reform, global financial influences, and recovery efforts following the COVID-19 pandemic.

D. Cumulative Growth Analysis

To underscore the scale of China's economic expansion, we calculated cumulative GDP growth for each country from 2000 to 2023. This analysis, presented in Figure 3, reveals that while the United States experienced steady and modest growth, China's cumulative growth has been exponential. Since 2000, China's GDP has increased by over 1,400%, compared to a much smaller relative increase in the United States. This cumulative growth difference highlights China's evolving position in the global economy and suggests that, if these trends persist, China's economic output could approach parity with that of the United States in the foreseeable future.

Fig. 3. Cumulative GDP Growth of China and the United States (2000- 2023)

E. Summary of Findings

These visualizations collectively illustrate the rapid eco- nomic expansion of China and its implications for the United States. While the US remains the world's largest economy in absolute terms, the narrowing gap in economic output, driven by China's accelerated growth, underscores China's rising influence and competitiveness on the global stage. This GDP analysis provides a foundational perspective on the broader economic relationship between the two nations and sets the stage for evaluating the potential risks and opportunities presented by China's continued ascent.

III. TRADE BALANCE ANALYSIS BETWEEN THE US AND CHINA

In examining the economic relationship between the United States and China, we focused on the trade balance between the two countries from 2000 to 2023. This analysis highlights long-term trends, seasonal patterns, and the impact of key economic events on trade dynamics.

A. Data Collection and Processing

To obtain trade balance data, we scraped monthly US- China trade figures from the US Census Bureau's Foreign Trade Division website [?]. Using Python's requests library, we sent a GET request to retrieve the HTML content of the webpage, which was then parsed with BeautifulSoup to extract each year's monthly export, import, and balance data. Our script iterated through each year, filtering out aggregate totals and structuring the monthly records into a DataFrame. Finally, we saved the data in an SQLite database for efficient querying and further analysis.

For interpretability, we converted monthly trade balance values into billions of USD. We also computed a 12-month rolling average to smooth short-term fluctuations and reveal the underlying trend.

B. Long-Term Trends in Trade Balance

It presents the monthly trade balance between the US and China over time. The purple line illustrates trade balance fluctuations, while the orange dashed line shows a 12-month rolling average to highlight long-term trends. A steadily in- creasing trade deficit with China is evident over the past two decades, with key economic events marked to contextualize shifts in the trend:

- **US-China Trade War (2018):** Initiated in 2018, the US- China trade war aimed to reduce the US trade deficit with China through tariffs on Chinese imports. While there was an initial reduction in the deficit, the long-term trend continued largely unaffected.
- **COVID-19 Pandemic Impact (2020):** The pandemic triggered a spike in the US trade deficit with China, reaching a new high. This increase likely reflects supply chain disruptions and changes in consumer demand, as the US relied heavily on imports for essential goods and personal protective equipment.

These findings suggest that despite policy interventions and global disruptions, the structural trade deficit between

the US and China has persisted, underscoring the extent of the US's dependence on Chinese imports.

C. Seasonal Patterns in Trade Balance

To further analyze the trade dynamics, we examined seasonal trends in the trade balance. It shows the average monthly trade balance across the entire period, revealing consistent seasonal fluctuations:

• **Higher Deficits in Spring:** The data indicates a re- curring trend of increased trade deficits in March and April. This may be due to increased consumer demand after the holiday season and the resumption of economic activities after the Lunar New Year in China.

• **Reduced Deficits in Late Summer and Fall:** The trade deficit tends to decrease toward the end of summer, hitting a low in September. This trend could reflect shifts in seasonal demand and inventory adjustments among US importers.

These seasonal insights suggest that the US trade balance with China is influenced not only by structural economic factors but also by regular seasonal patterns aligned with consumer and industrial cycles.

D. Summary of Findings

Our trade balance analysis illustrates the complexity of the US-China economic relationship. The persistent trade deficit highlights the reliance of the US on Chinese imports, which remains resilient even amidst policy interventions like tariffs and global disruptions such as the COVID-19 pandemic. The seasonal trends further emphasize that, in addition to structural dependencies, there are predictable fluctuations in trade balance tied to consumer demand cycles and international production schedules.

This trade balance analysis is instrumental in understanding the broader economic interdependence between the two nations, framing the context for potential vulnerabilities within the US supply chain and economic stability. As we delve deeper into specific sectors and dependency risks, these insights will inform a more targeted assessment of economic exposure and potential areas for policy adjustments.

IV. TECHNOLOGY SECTOR ANALYSIS

The technology sector is a critical area of focus in under- standing China's rising economic influence. With advancements in artificial intelligence, 5G, robotics, and quantum computing, China has positioned itself as a global leader in innovation. This section examines trends in China's technological growth using advanced web scraping techniques, sentiment analysis, and keyword tracking to analyze industry-specific data.

A. Data Collection and Processing

1) Web Scraping and Data Sources: To gather detailed insights into China's technological advancements, we ex- tracted data from the China Briefing website, which publishes articles related to industries, technology, economy, and regulatory changes. Using Python's selenium and BeautifulSoup, we scraped over 1,000 articles spanning multiple sections, ensuring comprehensive coverage of rele- vant topics.

Key scraping techniques included:

• Automated navigation of multi-page sections using
selenium to handle JavaScript-rendered content.

• Extraction of article metadata such as titles, publication dates, authors, and content using BeautifulSoup.

• Validation of extracted data with consistent error han-
dling to ensure clean and structured output.

Each article's content was tokenized and normalized using the nltk library. The processed data was stored in structured CSV files for downstream analysis. It illustrates the data pipeline, including scraping, preprocessing, and analysis.

2) APIs and External Datasets: In addition to web scrap- ing, we leveraged external datasets to contextualize our findings. For example:

• R&D spending data for China and the US was re- trieved using the World Bank API, accessing the GB.XPD.RSDV.GD.ZS indicator for annual spending as a percentage of GDP.

• Supplementary trade and technology data were acquired from the US Census Bureau and the World Economic Forum's public datasets.

This integration of scraped data with authoritative external sources provided a robust foundation for analysis.

3) Natural Language Processing (NLP): To extract meaningful patterns from textual data, we performed the following preprocessing steps:

• Tokenization and removal of stopwords, punctuation, and irrelevant terms using nltk.

• Sentiment analysis using the VADER lexicon to assess
the tone of articles within the technology sector.

• Keyword identification and frequency analysis to track mentions of terms such as AI, blockchain, and 5G.

These techniques enabled us to derive trends and sentiment distributions across thousands of articles, providing insights into the emphasis placed on different technologies over time.

B. Findings

1) Keyword Frequency Analysis: The keyword analysis revealed a significant focus on emerging technologies in recent years. As displays the top 20 most frequently mentioned terms in the dataset after preprocessing. Terms such as AI, data, and innovation dominate, reflecting the importance of technological development in China's economic strategy.

2) Sentiment Analysis: We performed sentiment analysis on articles across different sections to evaluate the tone of discussions. Articles in the Technology section exhibited overwhelmingly positive sentiment, highlighting optimism about China's progress in this area. Conversely, articles in the Legal & Regulatory section displayed more neutral sentiment, reflecting a balanced approach to policy-related developments.

3) Temporal Trends in Technology Mentions: To track the evolution of technological focus, we analyzed monthly mentions of key terms from 2010 to 2023. As it highlights sharp increases in the frequency of terms like AI, blockchain, and 5G beginning in 2018, coinciding with China's strate- gic investments in these areas. Peaks in mentions correlate with major policy announcements and international events, underscoring the link between government priorities and technological emphasis.

4) R&D Spending Analysis: Using World Bank data, we compared China's R&D spending to that of the United States from 2000 to 2023. China's steady increase in R&D expenditure as a percentage of GDP, nearing US levels by 2023. Predictions based on linear regression models suggest that China may surpass the US in R&D spending by 2035 if current trends persist.

C. Summary of Findings

The technology sector exemplifies China's strategic prioritization of innovation to enhance global competitiveness. Our analysis revealed:

• A sharp rise in mentions of emerging technologies such as AI, 5G, and blockchain in recent years, reflecting China's focus on technological leadership.

• Predominantly positive sentiment in technology-related articles, indicative of confidence in China's progress.

• A narrowing gap in R&D spending as a percentage of GDP between China and the United States, with projections suggesting parity by 2035.

These findings highlight the role of technology as both a driver of China's economic growth and a critical area of competition with the United States.

V. CONCLUSION

The evolving economic relationship between the United States and China is emblematic of both unprecedented global integration and intensifying strategic competition. This study underscores the dual nature of this relationship—marked by deep interdependence, particularly in trade and supply chains, alongside rising economic vulnerabilities and competitive pressures in critical sectors such as technology.

Our analysis of trade patterns from 2000 to 2023 reveals that the persistent US trade deficit with China reflects struc- tural dependencies that have proven resilient to policy inter- ventions, including tariffs and trade disputes. Seasonal fluc- tuations further illustrate predictable cycles of trade activity, driven by consumer demand and global production schedules, emphasizing the embedded nature of these economic ties.

Equally concerning is China's rapid ascent in the technol- ogy domain. Through state-supported initiatives, substantial R&D investment, and strategic prioritization of emerging technologies like artificial intelligence, 5G, and blockchain, China has positioned itself as a formidable global competitor. Our findings reveal a narrowing gap in R&D spending be- tween the US and China, alongside overwhelmingly positive sentiment within China regarding technological progress. If current trends continue, projections suggest that China could surpass the United States in R&D expenditure by 2035—a development with profound implications for global innovation leadership.

Collectively, these trends highlight that while the United States retains significant advantages in absolute economic scale and technological capability, the trajectory of China's growth presents tangible risks to US economic resilience, supply chain security, and global influence. Policymakers must therefore navigate this complex landscape by balancing cooperation where mutual benefits exist, while implementing strategic measures to mitigate vulnerabilities and safeguard national competitiveness.

VI. FUTURE WORK

While this study provides critical insights into the current state of US-China economic dynamics, several avenues for further research remain:

- **Sector-Specific Risk Analysis:** Future work should involve a more granular assessment of sectoral dependencies, particularly in high-risk areas such as semicon- ductors, rare earth elements, and critical pharmaceutical ingredients, to quantify potential supply chain disrup- tions.
- **Technological Innovation Pathways:** An expanded analysis of China's progress in advanced research fields—including quantum computing, biotechnology, green energy, and space technologies—would provide deeper insights into emerging areas of strategic competition.
- **Geopolitical Impact Assessment:** Further studies should explore how China's economic rise and technological advancements are reshaping global alliances, trade agreements, and international institutions, with a focus on potential policy responses from the United States and its allies.
- **Resilience and Diversification Strategies:** Research on effective strategies to enhance US supply chain resilience, diversify sourcing away from high-risk dependencies, and foster domestic manufacturing and innovation ecosystems would be vital for informing national policy debates.
- **Scenario-Based Projections:** Developing simulation models to explore potential future trajectories under different geopolitical, economic, and policy scenarios could aid in understanding the long-term implications of US-China economic dynamics.

By addressing these areas, future research can provide a more comprehensive understanding of the evolving US-China relationship and support evidence-based policymaking aimed at strengthening US economic security and technological leadership in an increasingly multipolar world.

REFERENCES

[1] J. Li and A. Roberts, "The Shifting Landscape of US-China Trade: Trends and Forecasts," Journal of International Economics, vol. 88, pp. 45–60, 2023.
[2] K. Zhang and M. Feldman, "AI Supremacy: China's Race to Lead Global Innovation," IEEE Transactions on Emerging Topics in Computing, vol. 11, no. 2, pp. 210–223, Apr. 2023.
[3] P. Singh and D. Lee, "Post-Pandemic Trade Patterns: A Quantitative Analysis of US-China Dependencies," Global Economic Review, vol. 52, no. 1, pp. 15–29, Jan. 2023.
[4] Y. Wang et al., "Blockchain Implementation Trends in China: A Policy and Industry Review," IEEE Access, vol. 11, pp. 125678–125690, 2023.
[5] S. Kumar and L. Zhao, "Sentiment Analytics in Technology Fore- casting: A Case Study of China's Tech Sector," IEEE Transactions on Computational Social Systems, vol. 10, no. 3, pp. 340–350, Mar. 2024.
[6] H. Park and T. Nguyen, "The Impact of Strategic Tech Investments on Global R&D Competitiveness," Technology in Society, vol. 78, Article 102345, 2024.
[7] M. Cheng and J. R. Harris, "Analyzing R&D Trends: The US and China in the Post-COVID Era," IEEE Transactions on Engineering Management, vol. 71, no. 1, pp. 85–97, Feb. 2024.
[8] B. Lin and F. Gao, "Evaluating the Role of 5G in Sino-American Economic Rivalry," Telecommunications Policy, vol. 47, no. 2, Article 102456, 2023.
[9] E. Brown, "US-China Trade War: Impact and Structural Conse- quences," World Trade Review, vol. 22, no. 1, pp. 65–79, Jan. 2023.
[10] A. Tanaka, "Techno-nationalism in East Asia: The China-US Innova- tion Rivalry," Asian Economic Policy Review, vol. 19, no. 1, pp. 11–25, Apr. 2024.
[11] C. Huang and M. Patel, "China's AI Boom: R&D Metrics and Policy Perspectives," IEEE Intelligent Systems, vol. 39, no. 1, pp. 30–39, Jan. 2024.
[12] N. Sharma, "Supply Chain Risks and Dependency: Lessons from US- China Economic Tensions," Supply Chain Management Review, vol. 45, no. 2, pp. 78–91, Mar. 2023.
[13] T. Wei and L. Jackson, "AI Policy Evolution in China and its Global Implications," IEEE Transactions on Technology and Society, vol. 5, no. 1, pp. 55–66, Feb. 2024.
[14] M. Ali and Y. Chen, "Emerging Blockchain Strategies in China's Financial Sector," Journal of Financial Technology, vol. 8, no. 1, pp. 102–114, Jan. 2023.
[15] K. Lee and B. Su, "Forecasting National R&D Expenditures Using Machine Learning: China vs. USA," IEEE Transactions on Big Data, Early Access, 2024.
[16] D. Morales, "Economic Interdependence in the 21st Century: The US- China Case," Global Affairs Review, vol. 16, no. 2, pp. 201–215, Apr. 2023.
[17] S. Wu et al., "Web Mining for Economic Insights: Tracking Techno- logical Momentum in China," IEEE Transactions on Knowledge and Data Engineering, vol. 36, no. 4, pp. 800–812, Apr. 2024.
[18] L. Fernandez and R. Tan, "Measuring Sentiment in Financial and Technological News: Evidence from China," IEEE Transactions on Affective Computing, Early Access, 2024.