Trade Dynamics in Post-Independence Kyrgyzstan: Analyzing the Shifts in Exports and Imports in the

Wake of Global Changes and the COVID-19 Pandemic

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Abstract

The study examines the significant shifts in Kyrgyzstan's trade dynamics since its independence, with a focus on the period post-2006. This era reveals a worrying trend of declining exports and rising imports, affecting the nation's economic balance. The research highlights how global changes, including the COVID-19 pandemic, have further complicated these dynamics, causing deviations from established trade patterns. Employing a combination of regression and time series analysis, along with forecasting methodologies, the study aims to provide an in-depth understanding of these trade shifts. Key areas of focus include the impact of the COVID-19 pandemic, the role of re-export activities, particularly to Russia, and the influence of global market trends on Kyrgyzstan's trade. The research also explores the potential economic risks associated with the observed trade imbalance and seeks to offer strategic insights for policy adjustments. This study is particularly relevant for identifying underlying causes of the current trade scenario in Kyrgyzstan and understanding the broader economic implications, thereby assisting in strategic planning and policy formulation to address the trade challenges faced by the country.

Keywords: Kyrgyzstan, trade dynamics, export-import analysis, COVID-19 impact, global market trends, regression analysis, time series analysis, economic policy, trade imbalance, re-export activities.

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Since gaining independence, Kyrgyzstan has experienced significant changes in its trade

dynamics, particularly from 2006 onwards. This period is marked by a consistent decrease in exports and

a significant increase in imports, affecting the entire nation, not just the capital, Bishkek. This trend

raises concerns about the country's growing reliance on foreign commodities, potentially impacting the

standard of living and leading to rising domestic prices (Pozdnyakova, 2023).

The COVID-19 pandemic has further complicated these trade dynamics, potentially exacerbating

existing imbalances (Aitbaev, 2022). While import volumes have largely recovered, following

predictions, export figures have exceeded initial forecasts, despite a noticeable decline in 2019

(Kerimbekov, 2022). This pattern highlights a concerning overreliance on external trade, emphasizing

the need for a deeper investigation into these shifts (Akeneyev, 2023).

In response to data limitations, our study has shifted from a regional analysis to a broader

national perspective, integrating various aspects of Kyrgyzstan's economic landscape. Through a

multifaceted approach, including regression analysis, time series analysis, and forecasting

methodologies, we aim to unravel the intricate patterns of trade dynamics and their broader economic

implications for Kyrgyzstan. Particular attention will be given to the scale and nature of re-export

activities to Russia, as this represents a significant factor in the nation's trade relationships (Van der

Kley, 2020).

This research aims to identify the underlying causes contributing to the increasing import and

decreasing export trends in Kyrgyzstan, focusing specifically on the impact of the COVID-19 pandemic.

By examining factors such as global market changes, regional policies, internal production shifts, and the

influence of geopolitical events like the Ukraine war (Aibashov, Biybosunov, & Rickleton, 2023), we

strive to develop a comprehensive understanding of the economic risks associated with the observed

trade imbalance. Additionally, we aim to analyze post-COVID-19 data in comparison to forecasted figures, highlighting substantial deviations and exploring their implications on the nation's economic outlook.

<div align="center">**Mathematical Model of the Problem**</div>

In our study of Kyrgyzstan's trade dynamics, we employ a mathematical model combining regression analysis and time series analysis, supplemented with forecasting techniques. This model is designed to dissect the complex interplay of factors influencing the nation's trade patterns and to provide a predictive view of future trends. Here's how we've structured this model:

Variables and Parameters:

- **Dependent Variables**: The primary focus is on export and import volumes, which are treated as dependent variables in our model.

- **Independent Variables**: These include time (considered in months or years), regional characteristics, global economic indicators, national policies, and currency valuation. Each of these variables is hypothesized to have a significant impact on the dependent variables.

Assumptions and Limitations:

- **Assumptions**: The model operates on the premise that historical trends can be indicative of future behavior. It also assumes that regions within Kyrgyzstan are subject to similar national policies and economic conditions.

- **Limitations**: A major limitation is the model's inability to account for sudden, unpredictable shifts in the global economy or abrupt changes in national policies. Additionally, it assumes uniformity in the impact of global conditions across all regions, which may not always hold true.

Analytical Techniques:

- **Regression Analysis**: This is utilized to understand the relationships between the dependent and independent variables, providing insights into how changes in policy, global economics, or regional characteristics might affect trade volumes.

- **Time Series Analysis**: We analyze historical data to identify trends, patterns, and potential anomalies in export and import volumes over time.

- **Forecasting**: Employing methods like ARIMA (AutoRegressive Integrated Moving Average), we forecast future trends in trade based on historical data, adjusted for any identified patterns or anomalies.

Exploring Export-Import Balance:

- **Trade Balance Calculation**: We calculate the trade balance by subtracting imports from exports. This figure is critical in assessing the nation's economic health.

- **Economic Indicators**: The trade balance provides insights into various economic aspects like the health of the economy, standard of living implications, and the status of foreign exchange reserves.

The application of this mathematical model is expected to yield critical insights into the causes and consequences of the observed trade patterns in Kyrgyzstan. By understanding these dynamics, we aim to offer actionable recommendations for policy adjustments and strategic planning to address the imbalances in trade and mitigate associated risks.

The integration of regression and time series analysis, along with sophisticated forecasting methods, ensures a robust, data-driven foundation for our study. These techniques, combined with a careful consideration of the underlying assumptions and limitations, provide a comprehensive framework for analyzing and predicting Kyrgyzstan's trade dynamics in the context of both regional and global economic landscapes.

Population and Sampling Method

In this study, we focused on the broad picture of Kyrgyzstan's trade dynamics, encompassing

data from all regions, including the capital, Bishkek. This approach allowed us to gain a comprehensive

understanding of the country's import and export trends on a national scale. Given our focus on the

overarching trade patterns of the entire nation, we did not employ intensive sampling techniques

typically used for analyzing smaller, more specific subsets of data. However, in cases requiring focused

investigation, we employed stratified sampling to guarantee representation from each relevant

category.

Data Collection Process

In our research, we employed a structured and efficient approach to data collection and

preparation, ensuring the relevance and accuracy of the data used. Below is an overview of this process:

1. **Sources of Data:**

   • **Primary Data Source:** Our primary data was obtained from the National Statistical Committee of

     the Kyrgyz Republic, ensuring official and reliable statistics.

   • **Data Categories:**

     • *External Trade*: In-depth data on Kyrgyzstan's imports and exports.

     • *National Accounts*: Information on Gross Domestic Product (GDP) per capita at current

       market prices.

     • *Regional Statistics*: Data on the production of main types of agricultural products in

       different regions.

     • *Retail Trade Turnover*: Turnover data from retail and catering enterprises across all sales

       channels and regions.

     • *Foreign and Mutual Trade*: Detailed insights into foreign and mutual trade activities,

       categorized by regions.

2. **Data Processing and Preparation:**

   • **Initial Analysis:** We reviewed GDP per capita data but decided to focus more on the directly

      relevant import and export data.

   • **Shift in Focus:** Our analysis primarily concentrated on import and export data classified by

      economic activities, aligning closely with our research objectives.

   • **Data Cleaning:** The data was cleaned and organized using Pandas, a Python data manipulation

      library. This step was crucial for enhancing the quality and usability of the data.

   • **Further Manipulation:** Additional data manipulation was carried out through Python scripts to

      refine the datasets for analysis.

3. **Data Representation:**

   • **Visualization Tools:** A variety of graphs and charts were employed to illustrate the trade trends.

   • **Time Series Analysis:** This included plotting total exports and imports over time, highlighting

      significant trends and changes, particularly in recent years.

   • **Comparative Analysis:** We overlaid import and export graphs to observe the divergence in trade

      balance, with a notable increase in disparity post-2006.

   • **Regional Focus:** Heatmaps and bar charts were utilized to demonstrate trade balances and

      activities, especially highlighting the role of Bishkek.

3. **Comprehensive Scope:**

   • **Broad Coverage:** Our methodology ensured a comprehensive coverage of Kyrgyzstan's trade

      dynamics, reflecting a complete picture of the nation's economic scenario.

This systematic approach to collecting and preparing data was essential in providing a solid foundation

for our in-depth analysis and subsequent findings.

Data Visualization and Analysis

In this section, we present and interpret various graphs and visual representations that provide

insights into Kyrgyzstan's trade dynamics. These visual tools have helped us to unravel trends,

correlations, and anomalies within the data.

Time Series Analysis:

Figure 1

Trend of Total Exports in Kyrgyzstan (2000-2022)
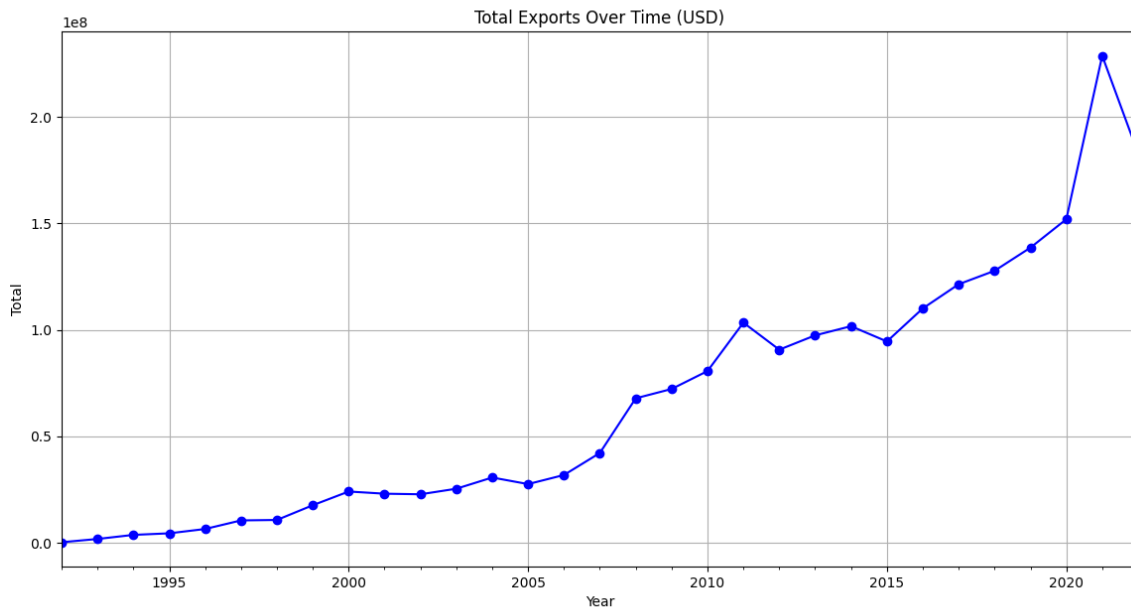
Note. This graph displays the fluctuating export values over the years, with a notable spike in 2021

followed by a decline in 2022, highlighting the instability in the export sector.

Figure 2

Trend of Total Imports in Kyrgyzstan (2000-2022)
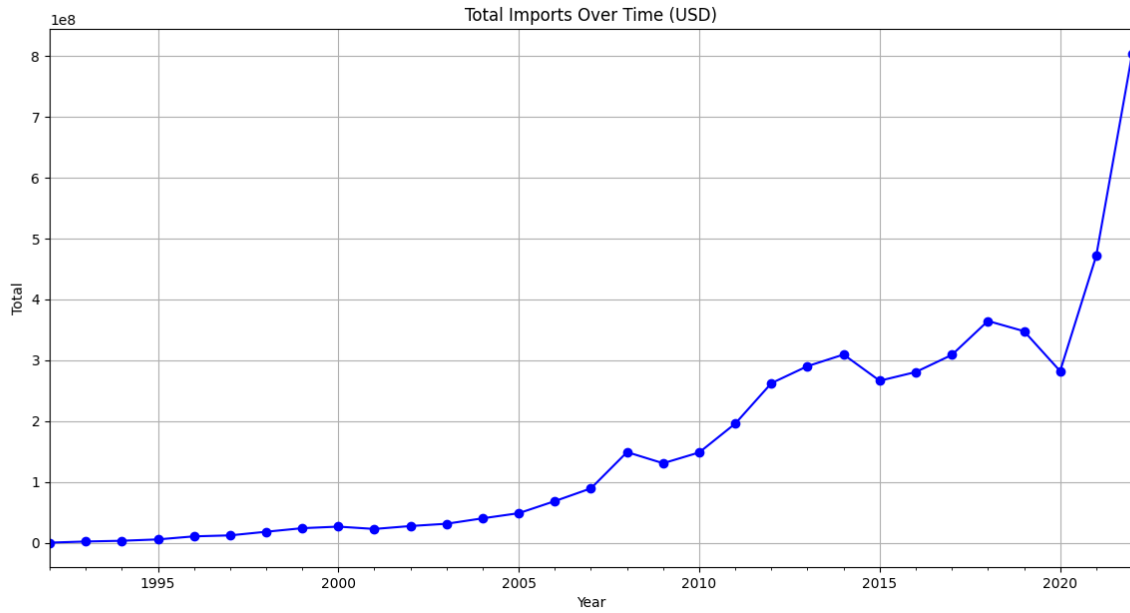
Note. The graph shows a steady increase in imports with significant spikes in 2021 and 2022, indicating a growing dependency on imported goods in Kyrgyzstan.

Figure 3

ARIMA Forecast of Kyrgyzstan's Trade Post-COVID
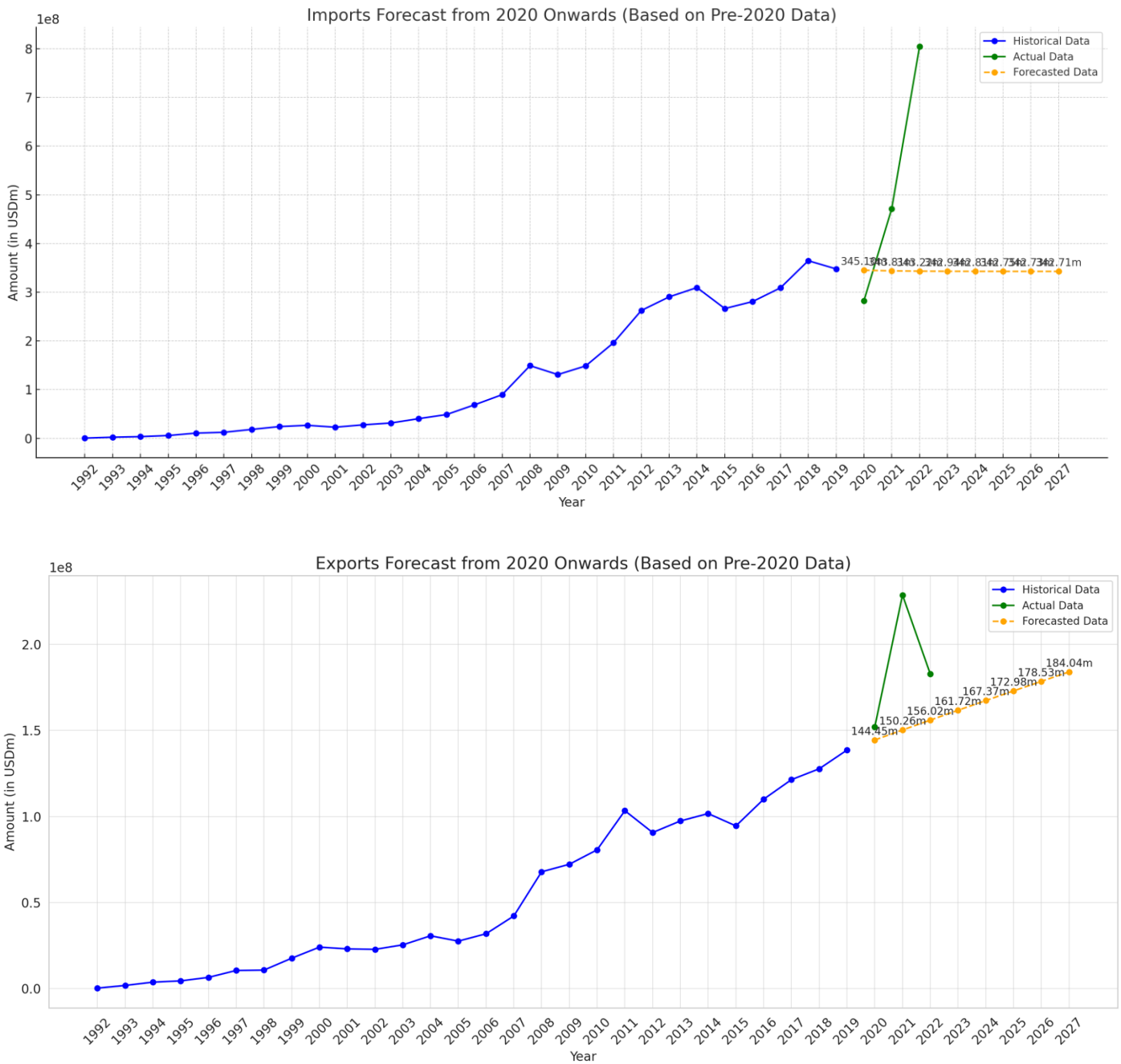
Note. These graphs show a steady increase in imports and exports with significant spikes in 2021 and

2022, indicating a growing dependency on imported goods in Kyrgyzstan.

Trade Balance Analysis:

Figure 4

Kyrgyzstan's Trade Balance (2000-2022)
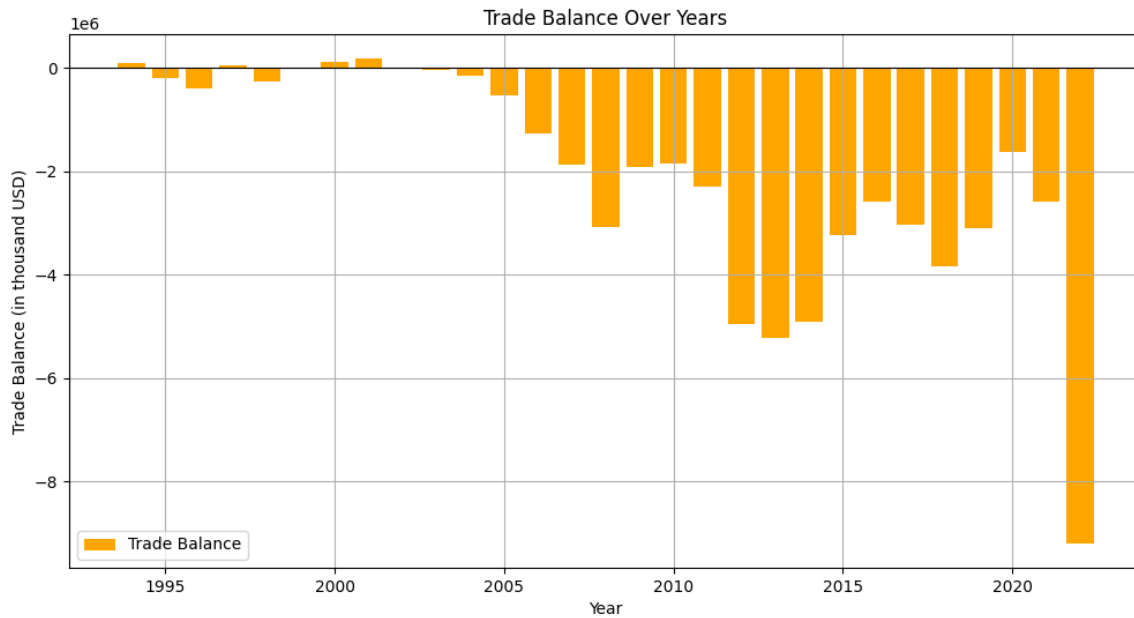
Note. This bar chart shows a significant drop in trade balance in 2022, signifying a growing trade deficit and potential economic challenges.

Figure 5

Time Series Analysis of Trade Balance with Regression Trend
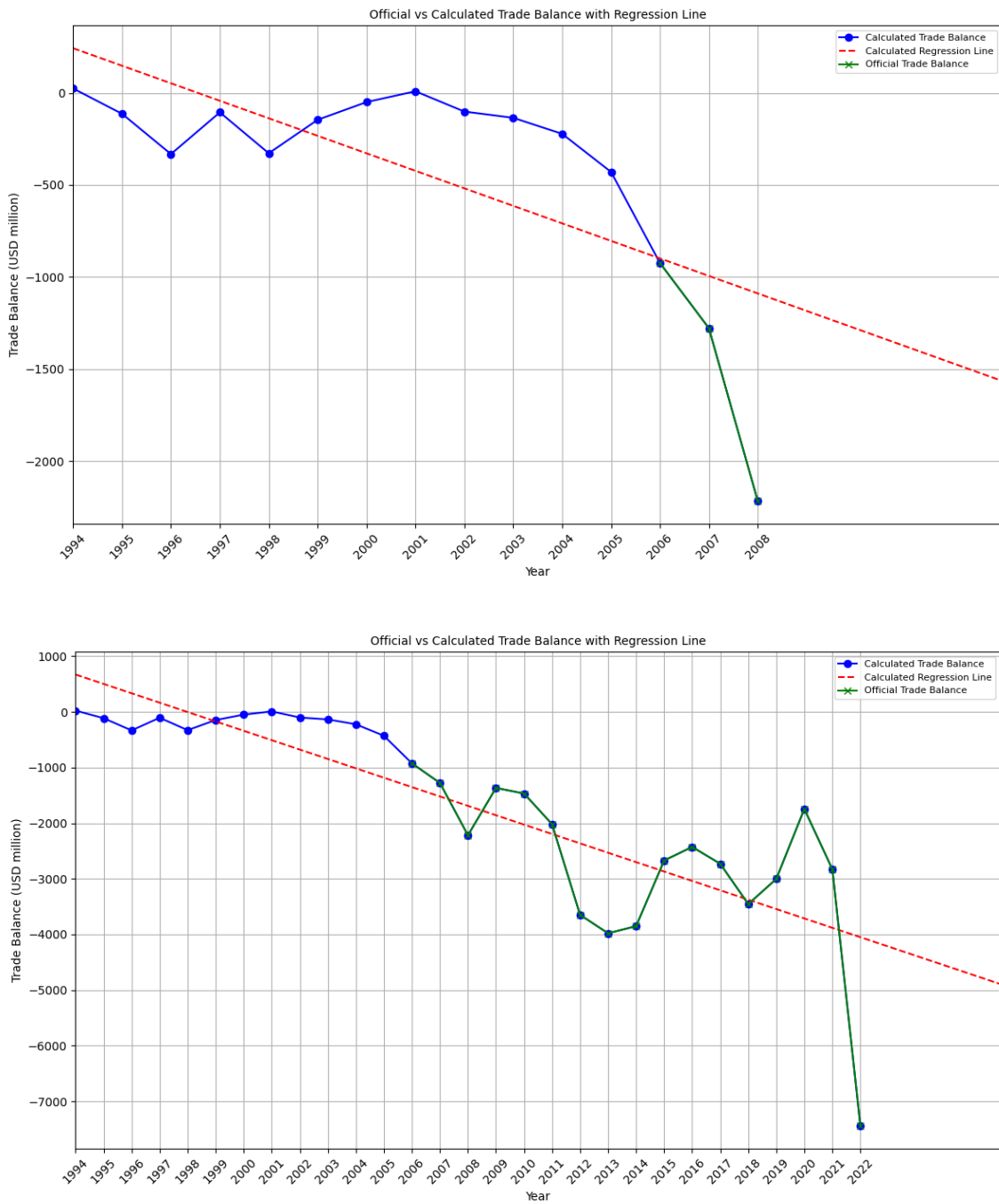
Note. These graphs includes both official and manually calculated trade balance data, consistently showing a downward trend, confirmed by the regression line.

Comparative Analysis of Imports and Exports:

Figure 6

Comparative Analysis of Imports and Exports in Kyrgyzstan (2000-2022)
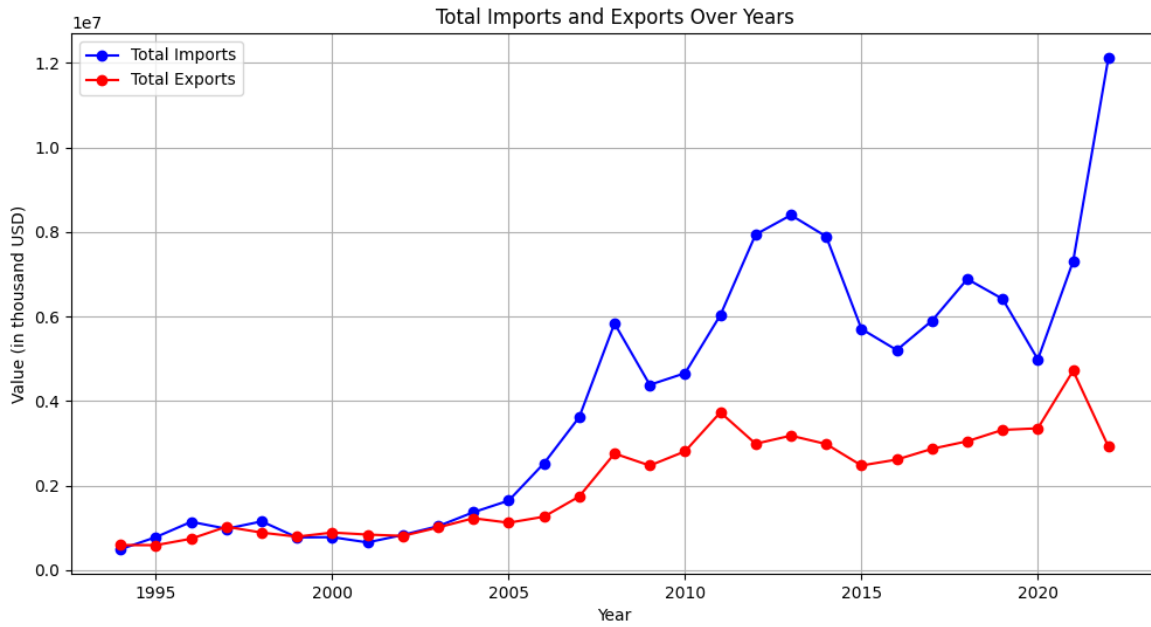
Note. This overlay graph illustrates the widening gap between imports and exports, particularly noticeable from 2006 onwards.

Year-to-Year Differences Analysis:

Figure 7

Year-to-Year Differences in Trade Balance (2000-2022)

Note. Highlights significant year-to-year changes in trade balance, with 2022 marked as an anomalous

year requiring further analysis.

Regional Trade Analysis:

Figure 8

Heatmaps of Import and Export Activities in Kyrgyzstan by Region (2022)

Heatmap of Regional Import Volumes by Year

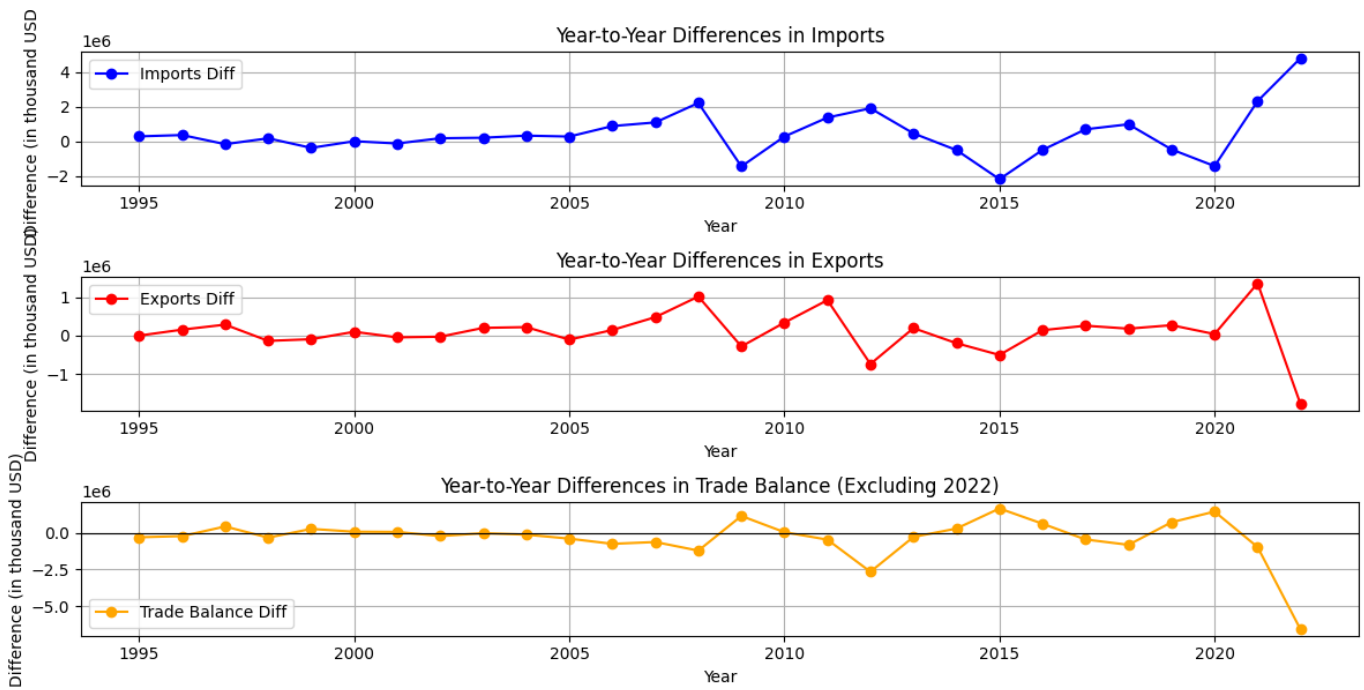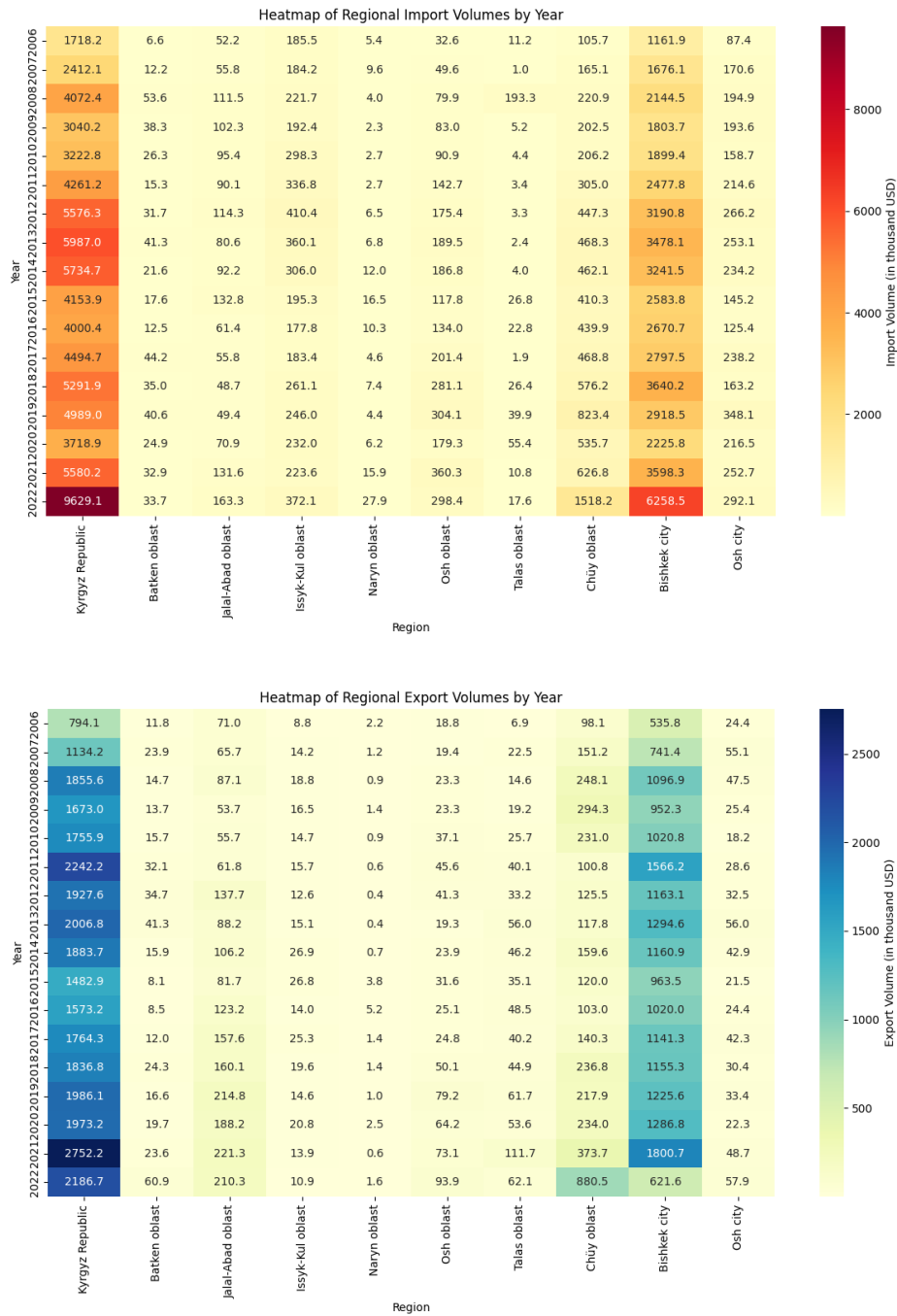| Year	Kyrgyz Republic	Batken oblast	Jalal-Abad oblast	Issyk-Kul oblast	Naryn oblast	Osh oblast	Talas oblast	Chüy oblast	Bishkek city	Osh city
2006	1718.2	6.6	52.2	185.5	5.4	32.6	11.2	105.7	1161.9	87.4
2007	2412.1	12.2	55.8	184.2	9.6	49.6	1.0	165.1	1676.1	170.6
2008	4072.4	53.6	111.5	221.7	4.0	79.9	193.3	220.9	2144.5	194.9
2009	3040.2	38.3	102.3	192.4	2.3	83.0	5.2	202.5	1803.7	193.6
2010	3222.8	26.3	95.4	298.3	2.7	90.9	4.4	206.2	1899.4	158.7
2011	4261.2	15.3	90.1	336.8	2.7	142.7	3.4	305.0	2477.8	214.6
2012	5576.3	31.7	114.3	410.4	6.5	175.4	3.3	447.3	3190.8	266.2
2013	5987.0	41.3	80.6	360.1	6.8	189.5	2.4	468.3	3478.1	253.1
2014	5734.7	21.6	92.2	306.0	12.0	186.8	4.0	462.1	3241.5	234.2
2015	4153.9	17.6	132.8	195.3	16.5	117.8	26.8	410.3	2583.8	145.2
2016	4000.4	12.5	61.4	177.8	10.3	134.0	22.8	439.9	2670.7	125.4
2017	4494.7	44.2	55.8	183.4	4.6	201.4	1.9	468.8	2797.5	238.2
2018	5291.9	35.0	48.7	261.1	7.4	281.1	26.4	576.2	3640.2	163.2
2019	4989.0	40.6	49.4	246.0	4.4	304.1	39.9	823.4	2918.5	348.1
2020	3718.9	24.9	70.9	232.0	6.2	179.3	55.4	535.7	2225.8	216.5
2021	5580.2	32.9	131.6	223.6	15.9	360.3	10.8	626.8	3598.3	252.7
2022	9629.1	33.7	163.3	372.1	27.9	298.4	17.6	1518.2	6258.5	292.1

Region — Import Volume (in thousand USD)

Heatmap of Regional Export Volumes by Year

Year	Kyrgyz Republic	Batken oblast	Jalal-Abad oblast	Issyk-Kul oblast	Naryn oblast	Osh oblast	Talas oblast	Chüy oblast	Bishkek city	Osh city
2006	794.1	11.8	71.0	8.8	2.2	18.8	6.9	98.1	535.8	24.4
2007	1134.2	23.9	65.7	14.2	1.2	19.4	22.5	151.2	741.4	55.1
2008	1855.6	14.7	87.1	18.8	0.9	23.3	14.6	248.1	1096.9	47.5
2009	1673.0	13.7	53.7	16.5	1.4	23.3	19.2	294.3	952.3	25.4
2010	1755.9	15.7	55.7	14.7	0.9	37.1	25.7	231.0	1020.8	18.2
2011	2242.2	32.1	61.8	15.7	0.6	45.6	40.1	100.8	1566.2	28.6
2012	1927.6	34.7	137.7	12.6	0.4	41.3	33.2	125.5	1163.1	32.5
2013	2006.8	41.3	88.2	15.1	0.4	19.3	56.0	117.8	1294.6	56.0
2014	1883.7	15.9	106.2	26.9	0.7	23.9	46.2	159.6	1160.9	42.9
2015	1482.9	8.1	81.7	26.8	3.8	31.6	35.1	120.0	963.5	21.5
2016	1573.2	8.5	123.2	14.0	5.2	25.1	48.5	103.0	1020.0	24.4
2017	1764.3	12.0	157.6	25.3	1.4	24.8	40.2	140.3	1141.3	42.3
2018	1836.8	24.3	160.1	19.6	1.4	50.1	44.9	236.8	1155.3	30.4
2019	1986.1	16.6	214.8	14.6	1.0	79.2	61.7	217.9	1225.6	33.4
2020	1973.2	19.7	188.2	20.8	2.5	64.2	53.6	234.0	1286.8	22.3
2021	2752.2	23.6	221.3	13.9	0.6	73.1	111.7	373.7	1800.7	48.7
2022	2186.7	60.9	210.3	10.9	1.6	93.9	62.1	880.5	621.6	57.9

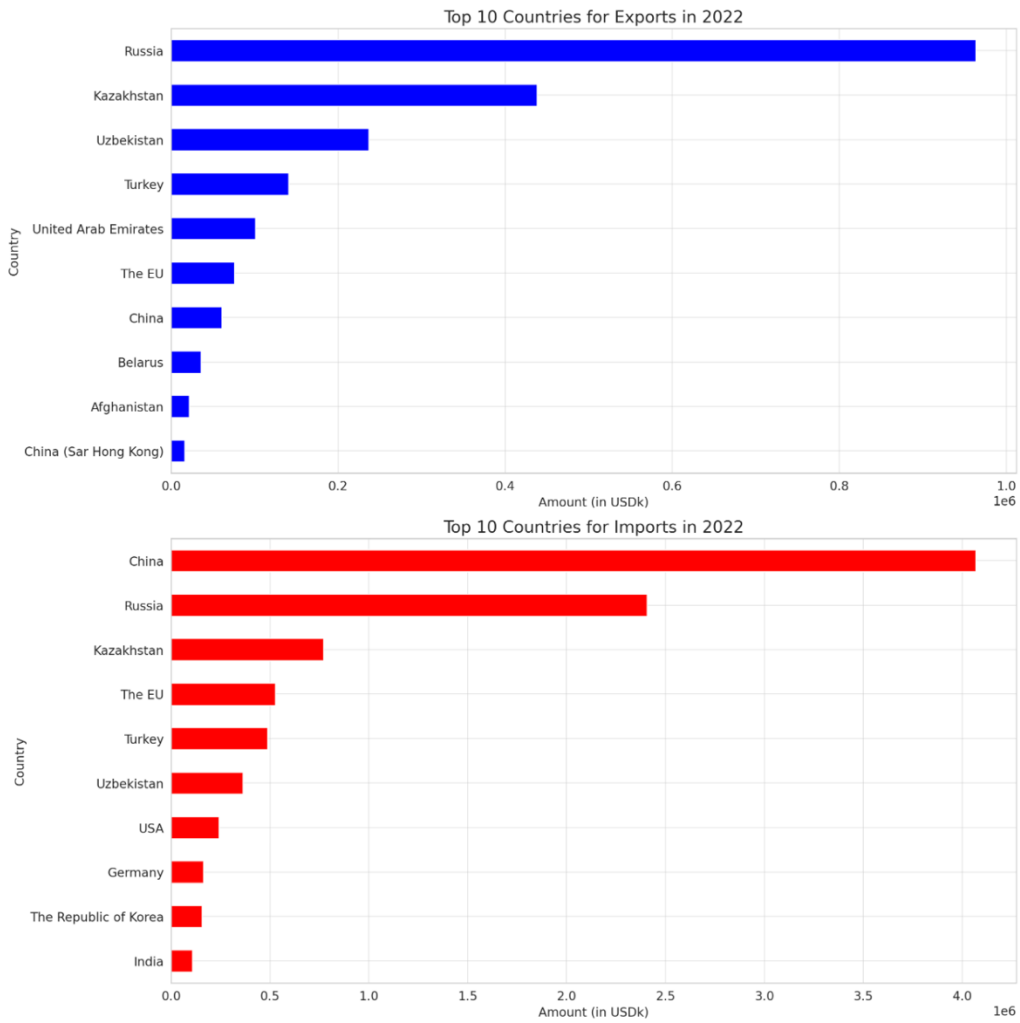*Region* — Export Volume (in thousand USD)

Note. These heatmaps emphasize Bishkek's dominant role in both import and export activities, with a notable surge in imports in 2022.

Geographical Trade Analysis

Figure 9

Top 10 Countries for Kyrgyzstan's Exports and Imports in 2022

Note. This horizontal bar chart displays the leading countries in terms of Kyrgyzstan's export and import activities for the year 2022.

These visual tools are integral to understanding both the current state and the future predictions of Kyrgyzstan's trade, pinpointing areas of concern and opportunities for strategic improvements.

Process and Solution

In our research, we adopted a detailed approach to analyze Kyrgyzstan's trade data, primarily sourced from the National Statistical Committee of the Kyrgyz Republic. Our first step was to clean and organize this data using Python's Pandas library, which was essential for ensuring accuracy and coherence.

We developed Python scripts for flexible data analysis, allowing us to generate various graphs and conduct diverse analyses. This approach enabled us to delve into different aspects of the trade data effectively. All our cleaned data, scripts, and analyses were systematically stored in a GitHub repository, ensuring easy access and the possibility of future collaborative work.

We applied regression analysis to understand the overall trend in trade balance, regardless of the time period chosen for analysis. The regression model indicated a consistent downward trend in trade balance. Additionally, we used the ARIMA model to analyze imports and exports separately, which revealed that both exports and imports had declined from their potential forecast, a divergence from expectations.

An analysis of year-to-year differences in trade figures highlighted substantial changes in recent years. For instance, a significant shift in trade dynamics was observed in the latest year of data, marked by either a sharp increase in imports or a significant decline in exports. This deviation called for a more nuanced understanding of the factors influencing these changes.

Detailed Sector Analysis

- **Agricultural Dependence**: A significant portion of Kyrgyzstan's exports is driven by agricultural products. This sector's vitality is crucial for the economy, but also exposes the country to risks associated with agricultural market volatility.

- **Textile Sector's Contribution**: The textile industry, particularly the export of clothing and accessories, emerged as a substantial component of the export economy. This indicates a competitive advantage in this sector which could be further leveraged.

- **Mining Sector's Impact**: The mining sector, especially gold mining, plays a pivotal role in Kyrgyzstan's export economy. Its fluctuating nature can significantly impact overall trade figures.

Energy Imports and Consumer Goods

- **Energy Reliance**: The analysis showed a heavy reliance on energy imports, such as diesel fuel and motor spirit, underscoring a vulnerability to global energy market shifts.

- **Increasing Consumer Goods Imports**: There's a growing trend in importing consumer goods, which suggests rising consumer demand but also reflects a gap in domestic production capabilities.

Trade Balance and Economic Health

- **Downward Trend in Trade Balance**: Despite varying periods, the trade balance consistently showed a downward trend, indicating persistent trade deficits. This trend raises concerns about long-term economic sustainability.

- **Impact on Currency and Reserves**: A consistent trade deficit could impact Kyrgyzstan's foreign exchange reserves and currency value, influencing overall economic stability.

Response to External Shocks

- **COVID-19 Pandemic Impact**: The analysis revealed how the COVID-19 pandemic affected trade dynamics, with a recovery in import volumes but an unexpected rise in exports, diverging from pre-pandemic trends.

- **Global Market Changes**: The study also accounted for the impact of global market changes, including the effects of geopolitical events like the Ukraine war, on trade patterns.

Possible Predictions Based on the Above Solution

As we synthesize our findings, it becomes clear that Kyrgyzstan's trade dynamics are not just shaped by internal economic activities but are also highly influenced by external geopolitical events and global market trends. Our analysis predicts that the future of Kyrgyzstan's trade will be significantly affected by these external factors.

The upward trend in Kyrgyzstan's re-export activities, particularly to Russia, as highlighted by Shabdanaliev (2022), suggests a potential area of growth. However, this also brings a degree of risk and uncertainty, especially considering the complex geopolitical landscape. The surge in trade with Russia, notably a sixfold increase in certain categories, indicates a shift in trade patterns that could have long-term implications for Kyrgyzstan's economy.

The COVID-19 pandemic has already demonstrated its impact, causing deviations from predicted trade patterns. While import volumes have shown resilience, the significant overperformance of exports compared to forecasts suggests an evolving trade landscape. This resilience, however, must be navigated cautiously, as the pandemic's long-term economic effects remain uncertain.

The analysis of year-to-year trade differences revealed concerning trends, especially the recent massive shift in trade dynamics. This shift, marked by an increase in imports and a decrease in exports, points to an emerging challenge in balancing trade and maintaining economic stability. The deviation from past trends calls for a deeper investigation into the factors driving these changes (Pozdnyakova, 2023).

Conclusion and Practical Recommendations

In response to these findings, it is crucial for Kyrgyzstan to develop strategic approaches aimed at diversifying its trade and reducing over-reliance on certain commodities and trade partners. Exploring new markets, such as the UK and other European countries, could open avenues for expanded trade relations, reducing the dependency on traditional markets like Russia and China.

Furthermore, the growing reliance on imports for essential commodities, as reported by

Kerimbekov (2022), underscores the need for domestic production enhancement. This strategy not only

reduces dependency on imports but also strengthens the nation's self-sufficiency, especially in vital

sectors such as agriculture and energy.

Given the dynamic nature of global trade, continuous monitoring and adaptive strategies are

essential. The country should invest in strengthening its analytical capabilities, utilizing advanced

statistical methods and forecasting models to better anticipate and respond to global trade shifts.

Finally, for future business analysts and policymakers, this study serves as a reminder of the

importance of a holistic approach to trade analysis. Understanding the interplay between domestic

economic policies, global market trends, and geopolitical events is key to developing robust trade

strategies. Nurturing such analytical skills will be crucial for the next generation of leaders in navigating

the complex terrain of international trade and economics.

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Appendix A

Python Script for ARIMA Calculation

```python
import os
import pandas as pd
from statsmodels.tsa.arima.model import ARIMA
import matplotlib.pyplot as plt

# Set up the directories
base_dir = os.path.dirname(os.path.dirname(__file__))  # This should navigate up to
the project root
data_dir = os.path.join(base_dir, 'data', 'processed')
output_dir = os.path.join(base_dir, 'output')

# Ensure the output directory exists
os.makedirs(output_dir, exist_ok=True)

# Constants
FORECAST_PERIOD = 7  # Change this value to forecast different periods
CUTOFF_YEAR = '2016'  # Change this to set the cutoff year for the historical data

# Function to load data, fit ARIMA model, and plot forecasts
def process_and_forecast(data_path, total_column, cutoff_year, forecast_period, title,
output_filename):
    # Load and preprocess the data
    data = pd.read_excel(data_path, index_col="Year", parse_dates=True)
    series = data[total_column]

    # Optionally filter out data from the specified cutoff year for analysis
    series_cutoff = series[:cutoff_year]

    # Fit the ARIMA model
    model = ARIMA(series_cutoff, order=(1,1,1))
    result = model.fit()

    # Forecast for the specified period
    forecast = result.forecast(steps=forecast_period)
    forecast_years = pd.date_range(start=series_cutoff.index[-1] +
pd.offsets.DateOffset(years=1), periods=forecast_period, freq='YS')

    print(f"{title} Forecast:", forecast)

    # Plot historical and forecasted data
    plt.figure(figsize=(15, 7))
    plt.plot(series, label='Historical Data', color='blue')  # Plot all data
    plt.plot(series_cutoff, label='Historical Data (Cutoff)', color='yellow',
linestyle='--')  # Plot up to cutoff
```

```python
    plt.plot(forecast_years, forecast, label='Forecasted Data', color='orange',
linestyle='--', marker='o')

    # Annotating the forecasted points
    for year, value in zip(forecast_years, forecast):
        plt.annotate(f"{value:.2f}", (year, value), textcoords="offset points",
xytext=(0,5), ha='center')

    plt.title(title)
    plt.xlabel('Year')
    plt.ylabel(total_column)
    plt.xticks(ticks=pd.date_range(start=series.index[0], end=forecast_years[-1],
freq='YS'), rotation=45)
    plt.grid(True)
    plt.legend()
    plt.tight_layout()

    # Save the plot
    output_path = os.path.join(output_dir, output_filename)
    plt.savefig(output_path)
    plt.close()  # Close the plot to free up memory

    print(f"Plot saved to {output_path}")

# Process exports data
exports_data_path = os.path.join(data_dir, 'exports', 'export_data.xlsx')
process_and_forecast(exports_data_path, 'Total', CUTOFF_YEAR, FORECAST_PERIOD,
'Exports Forecast', 'exports_forecast.png')

# Process imports data
imports_data_path = os.path.join(data_dir, 'imports', 'import_data.xlsx')
process_and_forecast(imports_data_path, 'Total', CUTOFF_YEAR, FORECAST_PERIOD,
'Imports Forecast', 'imports_forecast.png')
```

Appendix B

Python Script for General Trade Analysis

```python
import os
import pandas as pd
import matplotlib.pyplot as plt

# Set up the directories
base_dir = os.path.dirname(os.path.dirname(__file__))  # This should navigate up to
the project root
data_dir = os.path.join(base_dir, 'data', 'processed')
output_dir = os.path.join(base_dir, 'output')

# Ensure the output directory exists
os.makedirs(output_dir, exist_ok=True)

# Load the trade balance data
trade_balance_path = os.path.join(data_dir, 'Trade_Balance_by_Region_USDm.xlsx')
trade_balance_data = pd.read_excel(trade_balance_path, index_col='Year',
parse_dates=True)
trade_balance_data.index = trade_balance_data.index.year  # Keep only the year part

# Load the import and export data
import_goods_path = os.path.join(data_dir, 'imports/Imports_of_Main_Goods_USDk.xlsx')
export_goods_path = os.path.join(data_dir, 'exports/Exports_of_Main_Goods_USDk.xlsx')
import_goods_data = pd.read_excel(import_goods_path, index_col='Year',
parse_dates=True)
export_goods_data = pd.read_excel(export_goods_path, index_col='Year',
parse_dates=True)

# Adjusting the index to keep only the year part
import_goods_data.index = import_goods_data.index.year
export_goods_data.index = export_goods_data.index.year

# Summarize total imports and exports by year
total_imports_by_year = import_goods_data.sum(axis=1)
total_exports_by_year = export_goods_data.sum(axis=1)

# Create a plot for total imports and exports over the years
plt.figure(figsize=(12, 6))
plt.plot(total_imports_by_year.index, total_imports_by_year, marker='o', color='blue',
label='Total Imports')
plt.plot(total_exports_by_year.index, total_exports_by_year, marker='o', color='red',
label='Total Exports')
plt.title('Total Imports and Exports Over Years')
plt.xlabel('Year')
plt.ylabel('Value (in thousand USD)')
```

```python
plt.grid(True)
plt.legend()
plt.savefig(os.path.join(output_dir, 'total_imports_exports.png'))
plt.close()

# Calculate year-to-year differences for imports and exports
total_imports_by_year_diff = total_imports_by_year.diff()
total_exports_by_year_diff = total_exports_by_year.diff()

# Calculate the mean and standard deviation for imports and exports
mean_imports = total_imports_by_year.mean()
std_imports = total_imports_by_year.std()
mean_exports = total_exports_by_year.mean()
std_exports = total_exports_by_year.std()

# Identify outliers based on the 3-standard deviation criterion
outliers_imports = total_imports_by_year[(total_imports_by_year - mean_imports).abs()
> 3 * std_imports]
outliers_exports = total_exports_by_year[(total_exports_by_year - mean_exports).abs()
> 3 * std_exports]

# Create a plot for total imports and exports differences
plt.figure(figsize=(12, 6))
plt.plot(total_imports_by_year_diff.index, total_imports_by_year_diff, marker='o',
color='blue', label='Imports Diff')
plt.plot(total_exports_by_year_diff.index, total_exports_by_year_diff, marker='o',
color='red', label='Exports Diff')
plt.title('Year-to-Year Differences in Imports and Exports')
plt.xlabel('Year')
plt.ylabel('Difference (in thousand USD)')
plt.grid(True)
plt.legend()
plt.savefig(os.path.join(output_dir, 'imports_exports_diff.png'))
plt.close()
```

Appendix C

Python Script for Trade Analysis with Regression Comparison

```python
import os
import pandas as pd
import numpy as np
from sklearn.linear_model import LinearRegression
from sklearn.metrics import mean_squared_error, r2_score
import matplotlib.pyplot as plt

# Constant for cut-off year
CUT_OFF_YEAR = 2008

# Set up the directories
base_dir = os.path.dirname(os.path.dirname(__file__))  # Navigate up to the project
root
data_dir = os.path.join(base_dir, 'data', 'processed')
output_dir = os.path.join(base_dir, 'output')

# Ensure the output directory exists
os.makedirs(output_dir, exist_ok=True)

# Load the trade balance data
trade_balance_path = os.path.join(data_dir, 'Trade_Balance_by_Region_USDm.xlsx')
trade_balance_data = pd.read_excel(trade_balance_path)
trade_balance_data['Year'] = pd.to_datetime(trade_balance_data['Year']).dt.year
trade_balance_data.set_index('Year', inplace=True)

# Load the import and export data
import_goods_path = os.path.join(data_dir, 'imports/Imports_of_Main_Goods_USDk.xlsx')
export_goods_path = os.path.join(data_dir, 'exports/Exports_of_Main_Goods_USDk.xlsx')
import_goods_data = pd.read_excel(import_goods_path)
export_goods_data = pd.read_excel(export_goods_path)

# Convert 'Year' to datetime and extract the year as an integer, then set as index
import_goods_data['Year'] = pd.to_datetime(import_goods_data['Year']).dt.year
import_goods_data.set_index('Year', inplace=True)
export_goods_data['Year'] = pd.to_datetime(export_goods_data['Year']).dt.year
export_goods_data.set_index('Year', inplace=True)

# Convert import and export data from thousands to millions of dollars
import_goods_data = import_goods_data / 1000
export_goods_data = export_goods_data / 1000

# Fill missing values with 0
import_goods_data.fillna(0, inplace=True)
export_goods_data.fillna(0, inplace=True)
```

```python
trade_balance_data.fillna(0, inplace=True)

# Rename overlapping columns in import and export data to avoid conflicts
import_goods_data = import_goods_data.add_prefix('Import_')
export_goods_data = export_goods_data.add_prefix('Export_')

# Calculate the trade balance for all available years in the import and export
datasets
all_years_trade_balance = export_goods_data['Export_Total'] -
import_goods_data['Import_Total']
all_years_trade_balance.name = 'CalculatedTradeBalance'

# Join the calculated trade balance with the official trade balance data
full_trade_balance_data = trade_balance_data.join(all_years_trade_balance,
how='outer')

# Filter data based on the cut-off year
full_trade_balance_data = full_trade_balance_data[full_trade_balance_data.index <=
CUT_OFF_YEAR]
import_goods_data = import_goods_data[import_goods_data.index <= CUT_OFF_YEAR]
export_goods_data = export_goods_data[export_goods_data.index <= CUT_OFF_YEAR]

# Prepare data for linear regression for calculated trade balance
X_filtered = full_trade_balance_data.index.values.reshape(-1, 1)  # Year
y_filtered = full_trade_balance_data['CalculatedTradeBalance'].values  # Calculated
Trade Balance

# Create and fit the model for calculated trade balance
model_filtered = LinearRegression()
model_filtered.fit(X_filtered, y_filtered)

# Predict for 5 additional years (up to the cut-off year)
X_future_filtered = np.arange(X_filtered.min(), CUT_OFF_YEAR + 6).reshape(-1, 1)
y_pred_future_filtered = model_filtered.predict(X_future_filtered)

# Plotting official and calculated trade balance and regression line for calculated
trade balance
fig, ax = plt.subplots(figsize=(12, 7))
ax.plot(full_trade_balance_data.index,
full_trade_balance_data['CalculatedTradeBalance'], label='Calculated Trade Balance',
color='blue', marker='o')
ax.plot(X_future_filtered, y_pred_future_filtered, label='Calculated Regression Line',
color='red', linestyle='--')
ax.plot(full_trade_balance_data.index, full_trade_balance_data['Kyrgyz Republic'],
label='Official Trade Balance', color='green', marker='x')

# Setting x-ticks for each year in the index
ax.set_xticks(full_trade_balance_data.index)
```

```python
ax.set_xticklabels(full_trade_balance_data.index, rotation=45)  # Rotate labels for
better readability

# Extend the x-axis to accommodate future years and past years
ax.set_xlim([X_filtered.min(), X_future_filtered.max()])

ax.set_title('Official vs Calculated Trade Balance with Regression Line', fontsize=10)
ax.set_xlabel('Year', fontsize=10)
ax.set_ylabel('Trade Balance (USD million)', fontsize=10)
ax.legend(fontsize=8)
ax.grid(True)
plt.tight_layout()  # Adjust layout to prevent clipping of tick-labels
plt.savefig(os.path.join(output_dir,
'trade_balance_comparison_regression_filtered.png'))
plt.show()

# Print model statistics for calculated trade balance
print("Model Coefficients (Filtered):", model_filtered.coef_)
print("Intercept (Filtered):", model_filtered.intercept_)
print("Mean Squared Error (Filtered):", mean_squared_error(y_filtered,
model_filtered.predict(X_filtered)))
print("R^2 Score (Filtered):", r2_score(y_filtered,
model_filtered.predict(X_filtered)))
```