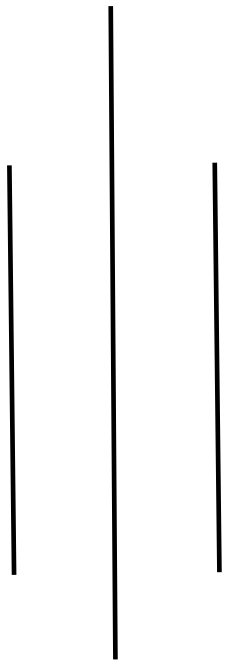
CMIS 567 - 73C, Data Analytics

Spring 1, 2025

Dynamic Impact of FDI, Inflation, and Exchange Rate on Trade Balance



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Executive Summary

Trade balance has always been a study of interest for economists and leading research institutes, as it plays a crucial role in shaping a country's economy. The significance of trade balance cannot be understated, as it measures a country's economic strength and competitiveness in the global market. [1]. This study aims to understand how fluctuations in exchange rates, inflation trends, and FDI flows influence trade balances in several countries across different economic groups. Through the help of this report, one can understand how these macroeconomic variables affect the trade balance of countries across different income groups in the long term. The data used for this report show persistent trade deficits, rising inflation, and disinflation episodes. In addition to that, this study can be a foundational model for predictive modeling, which can help to anticipate potential financial crises for countries.

The primary target audience of this project is the Institute of Development of Studies (IDS), which is researching and seeking to understand trade balance dynamics across low-income, lower-middle-income, upper-middle-income, and high-income economies. This study uses the data from the World Development Bank | Dataset. The methodology used for this project involves statistical analysis using a linear fixed effects regression model to examine the dynamic relationship between exchange rates, inflation, and FDI with trade balance. Since the dynamic between the dependent and independent variables in this study was quite complex, interaction terms were analyzed across different income groups.

The analysis reveals nuanced findings regarding the direct influence of exchange rate, inflation, and foreign development investments on trade balance. Classic traditional economic theories, such as the Marshall-Lennar condition, suggest that exchange rate depreciation should improve a country's trade balance; however, the empirical findings from this study reveal a more complex reality. The results indicate that, overall, the exchange rate hurts the trade balance. However, the findings were not uniform across different income groups. The interaction with different income groups shows that the trade balance of lower-middle-income countries is negatively affected, whereas upper-middle-income countries have a positive experience. Regardless of the positive or negative impact, the model was statistically significant, which supported the hypothesis. Similarly, the study investigates the impact of inflation on trade balance. The conventional economic theories suggest that inflation negatively affects trade balance; after conducting a deeper analysis on different income groups the inflation had a positive impact on trade balance in lower and upper middle-income countries across different regions, which contradicts our hypothesis that higher inflation leads to trade balance deterioration. This finding did not fully support the hypothesis. Another finding of this study is from the interaction terms with FDI, which reveals that FDI inflows have negatively affected the high-income European countries while FDI outflows seem to have a positive impact on trade balance. But both of their impact across different income groups reflects the complex relationship between FDI and trade balance. In short, this study underscores the multifaceted nature of trade balance determinants and challenges.

1. Introduction

International trade dynamics are linked to macroeconomic factors such as exchange rate, inflation, Foreign Development Investment (FDI), and interest rates. An increase in trade deficit and rising imports are negatively associated with a country's exchange rate and inflation because they create downward pressure on domestic currency and contribute to inflationary pressures. Additionally, fluctuations in these macroeconomic variables have large influences on many parts of the economy, such as wages, prices, production levels, and employment. These variables have a large impact on people's everyday lives and the standard of living [2]. Although metrics such as exchange rates, inflation, and foreign direct investment (FDI) have been studied quite a lot by many economists. This study aims to shed light on the relationship among real exchange rate, inflation, and the trade balance in the context of lower, middle- and high-income countries.

1.1. Aims and Objectives

The Institute of Development of Studies (IDS) is a research center at the University of Sussex, located in Brighton, UK. It works with partners around the world and research development economies, global trade, poverty alleviation, and economy policy [3]. One of the main focuses of their research is understanding how economic factors, such as inflation, exchange rates, and FDI, affect trade balance and development in different income levels. The goal of this study is to assist IDS to compare the impacts of these macroeconomic variables across different regions and income groups. The findings from this report will assist IDS in comparing the impact of these macroeconomic factors across different income groups and how they react differently.

The objectives are:

- To summarize the impact of macroeconomic factors on trade balance across different income groups.
- Provide foundational research for IDS to build a predictive model on this topic.

1.2. Problem Statement

There are currently many studies being conducted on trade balance and its impacts; many of this research tend to be broad and have a generalized view. There is a gap in understanding on how these factors specifically affect the trade balance across different income groups. The variations in the trade balance across these income groups are not studied sufficiently and remain unexplored.

1.3. Scope

The project's scope is centered around the study of macroeconomic factors and their impact on trade balance. The study will assist IDS to fill the existing gap by providing a comparative analysis of these factors, with a focus on how they impact countries at different income levels. The project will include data analysis, wrangling, modeling, and result interpretation. The overarching goal of this study is to support IDS's research and contribute to the development of region-specific policies and models.

2. Data and Methodology

This section explains sample data, development of research questions, hypothesis, and methodology used to conduct the analysis.

2.1. Sample Data

For this analysis, the World Development Indicators | Databank dataset with pre-existing data has been used. A " World Development Indicators | Databank " refers to a collection of economic and social data compiled by the World Bank. The countries were selected from three income categories, which were already pre-categorized by the World Bank as lower-middle-income countries, upper-middle-income countries, and high-income countries. From each category, 7-8 countries were chosen as sample data. The total number of countries selected was 22. The selection was done based on the availability of complete data, meaning countries with the least number of missing values were considered. The dependent variable taken for this research was Trade Balance, and the independent variables were exchange rate, inflation, and FDI.

Table 1 summarizes the final dataset of countries used for analysis.

Countries	
Low Middle Asia	Bangladesh, India, Pakistan, Philippines
Low Middle Africa Mena	Morocco, Kenya, Egypt Arab Rep.
Upper Middle Latin America	Mexico, Brazil, Costa Rica
Upper Middle Asia	Malaysia, Thailand, Indonesia, Türkiye
High Income Asia Pacific	Australia, Singapore, Japan, New Zealand
High Income Europe Na	United Kingdom, France, Canada, Sweden

Table 1: Categorized Data

Table 2 below provides a summary of the data

Variable	*Acronym*	*Definition*	*Data Type*	*Unit of Measure*
Name	Name	Country identifier	Character	-
Time	Time	Observation year	Time	-
Income Group	IG	Categorized as lower-middle, upper-middle, or high income	Categorical	-
Exchange Rate	ER	Official exchange rate	Numeric (continuous)	dollar ($)
Imports	IM	Goods and services imports	Numeric (continuous)	percentage
Exports	EX	Goods and services exports	Numeric (continuous)	percentage
Inflation	IF	Consumer price inflation	Numeric (continuous)	percentage
FDI, net inflows	FDI_NI	Foreign direct investments, inflows	Numeric (continuous)	percentage
FDI, net outflows	FDI_NO	Foreign direct investments, outflows	Numeric (continuous)	percentage
Trade Balance	TB	Exports - Imports	Numeric (continuous)	percentage

Table 2: Sample Data

2.2. Data Wrangling

The dataset contained some missing values, which needed to be handled. The missing values were primarily observed in variables (Inflation, Trade Balance, and FDI Net Outflows). To ensure data integrity and consistency was maintained across income groups, the following strategies were used.

- Inflation: Missing values for Brazil and Bangladesh from 1974 – 1976 were replaced with the median inflation rate of other countries within the same income group. This approach ensures consistency while preserving economic comparability.
- FDI Net Outflows: For the years 1974–1979, the missing FDI Net Outflows data for Low Middle-Income regions in Asia, Africa, and MENA was replaced with zeros. This adjustment was made to reflect the reality of the economy.
- Imports and Exports: The Philippines had missing import/export values from 1974 to 1979. These were replaced with the median import/export from other Upper-Middle-Income Asian countries to maintain regional consistency.

Additionally, the variables, such as exchange rates and inflation, had some outliers. To fix this issue and ensure that no misleading results were generated, a normalization technique was applied before conducting any analysis.

2.3. Data Exploration

To explore and understand simple trends in the data, scatter plots and bar chart was created in Figures 1, 2, 3, 4 and 5 below using R Studio

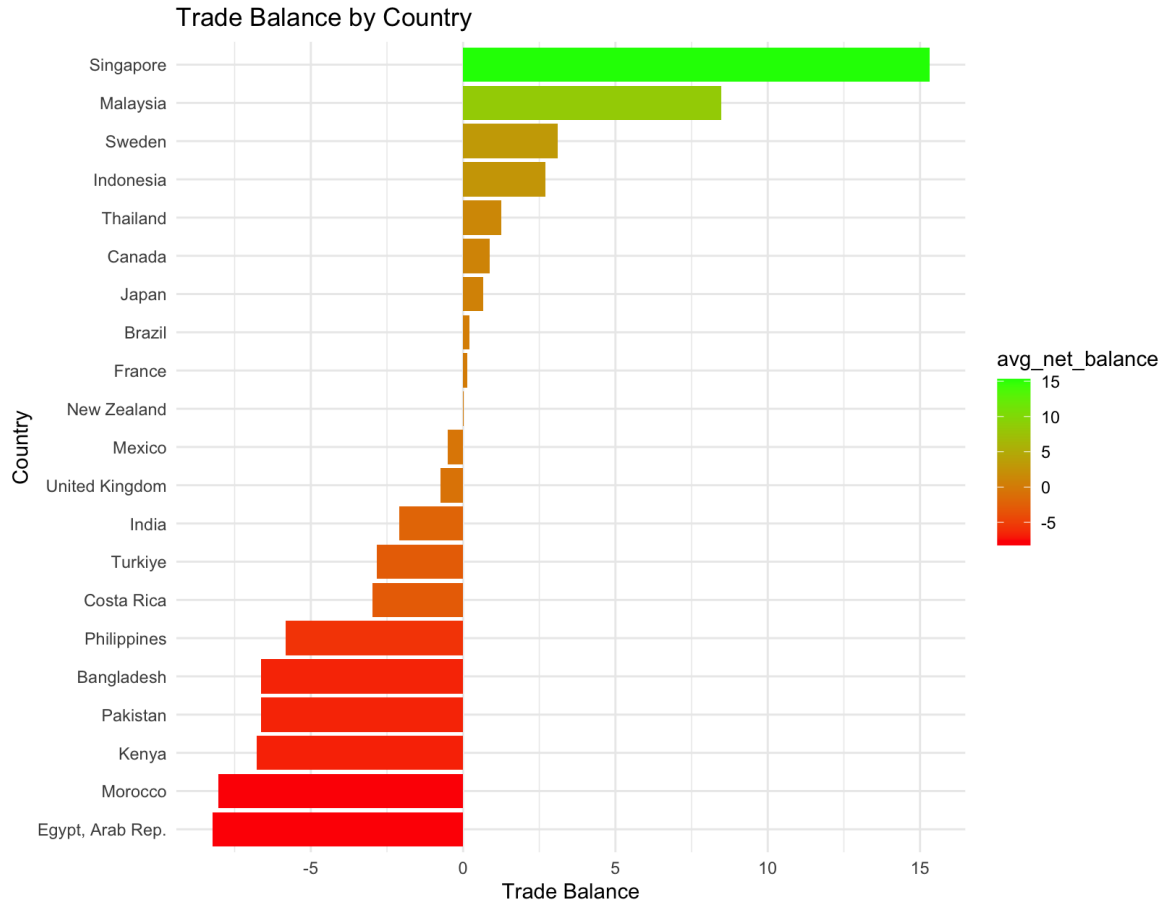

Figure 1: Trade Balance by Country

The bar chart from Figure 1 visualizes the trade balance by country. From the visualization, one can observe that Singapore has the highest trade surplus, which is followed by Malaysia, Sweden, and Indonesia. This means that these countries are export-heavy economies. On the other hand, Egypt, Morocco, Kenya, Pakistan, and Bangladesh are in trade deficit, which is sort of given as they have been classified as lower-income countries. It is interesting to see upper-middle-income countries such as Malaysia, Indonesia, and Thailand taking the top spots in the trade surplus countries despite being classified as upper-income countries in Asia.

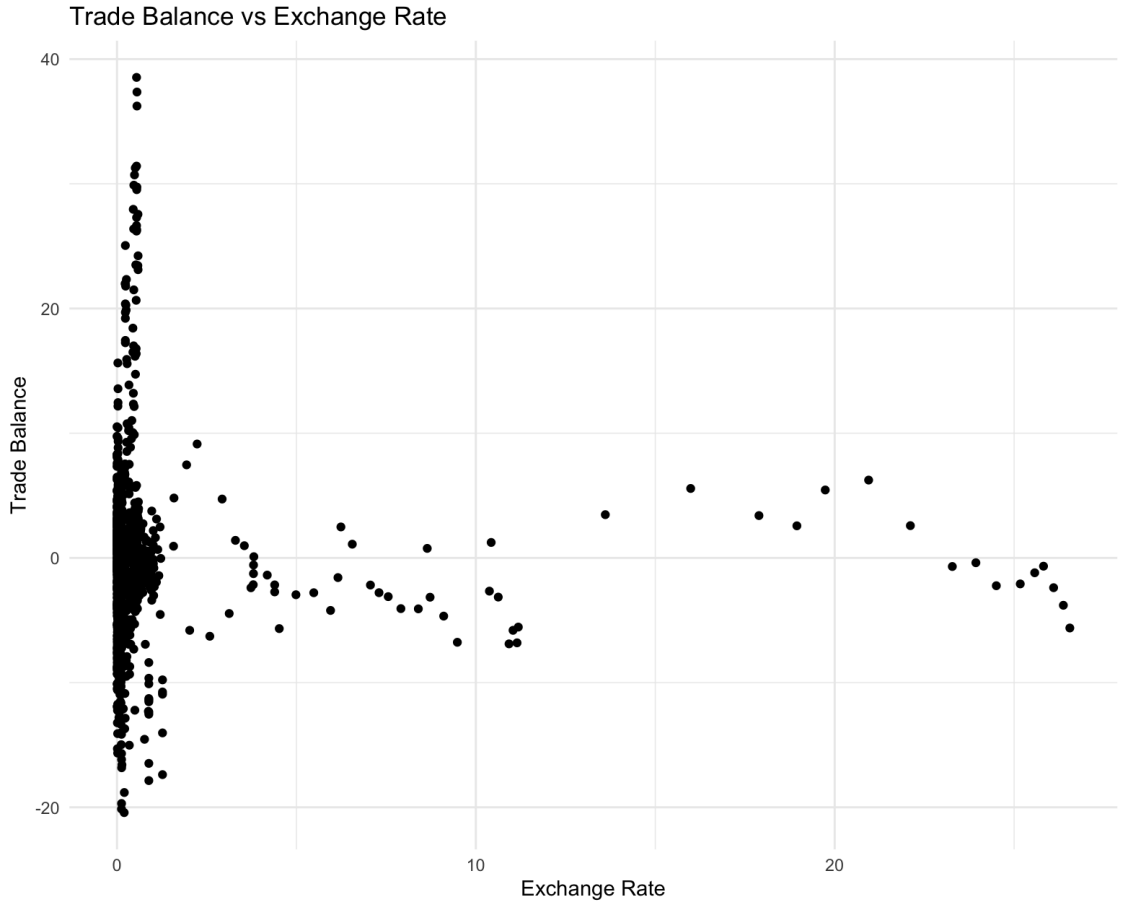

Figure 2: Scatter plot of TB vs ER

The scatter plot from Figure 2 visualizes the relationship between Trade Balance and Exchange Rate. From the visualization, one can observe that most of the data points are clustered near zero, meaning that many countries have relatively low exchange rates with respect to US dollars. There is also some variation in trade balance values, it shows that some countries have a high positive trade balance while some have a strong negative trade balance. There does not seem to appear any clear linear trend or any discerning relationship between exchange rates and trade balance, indicating that there are other factors that need to be considered such as trade policies, economic structure,etc.

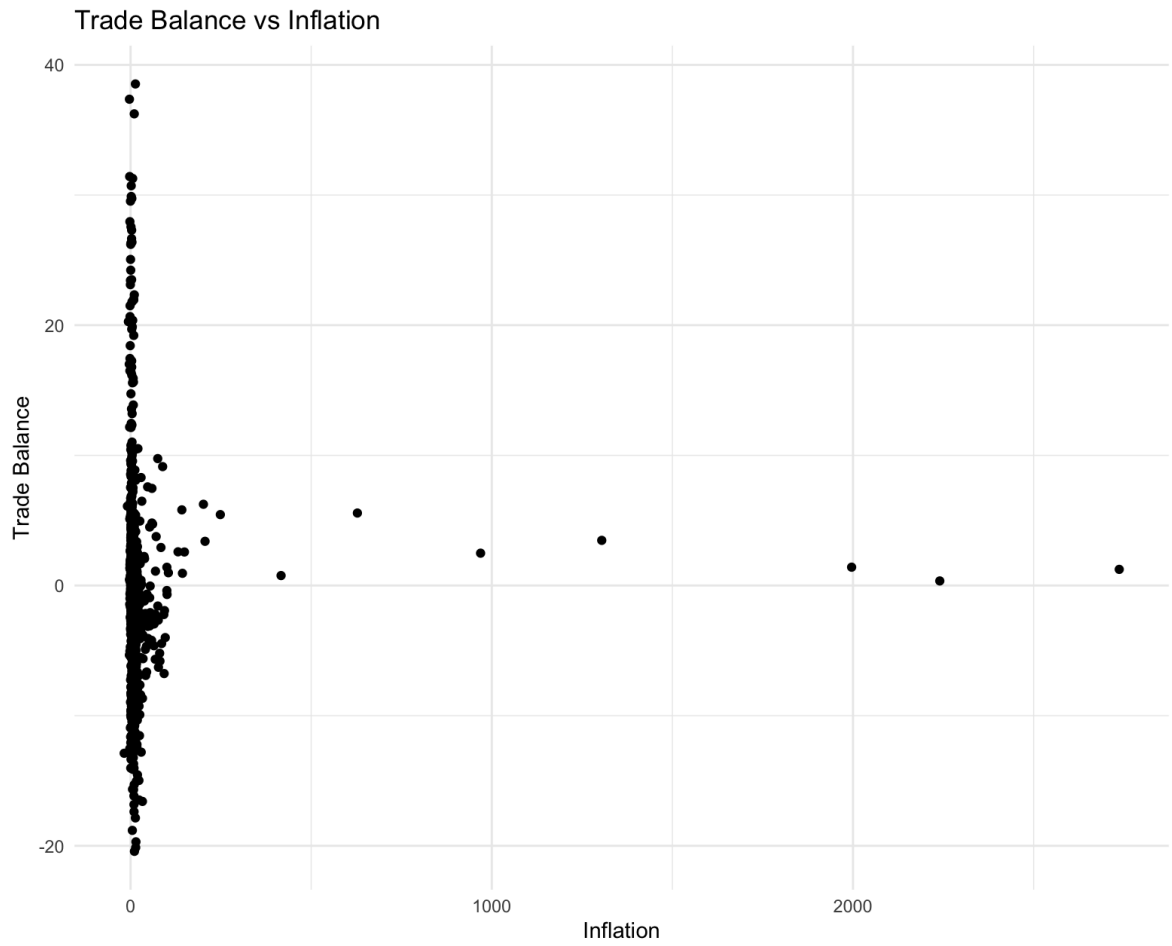

Figure 3: Scatter plot of TB vs IF

The scatter plot from Figure 3 visualizes the relationship between Trade Balance and Inflation. From the visualization, one can observe that most of the data points are clustered near zero, meaning that many countries have relatively low inflation. As inflation increases, there are fewer countries indicating that very a smaller number of have faced hyperinflation. Trade Balance seems to be dispersed, with no clear trend/relationship suggesting a correlation between inflation and trade balance, indicating there might be other macroeconomic factors that can play a significant role.

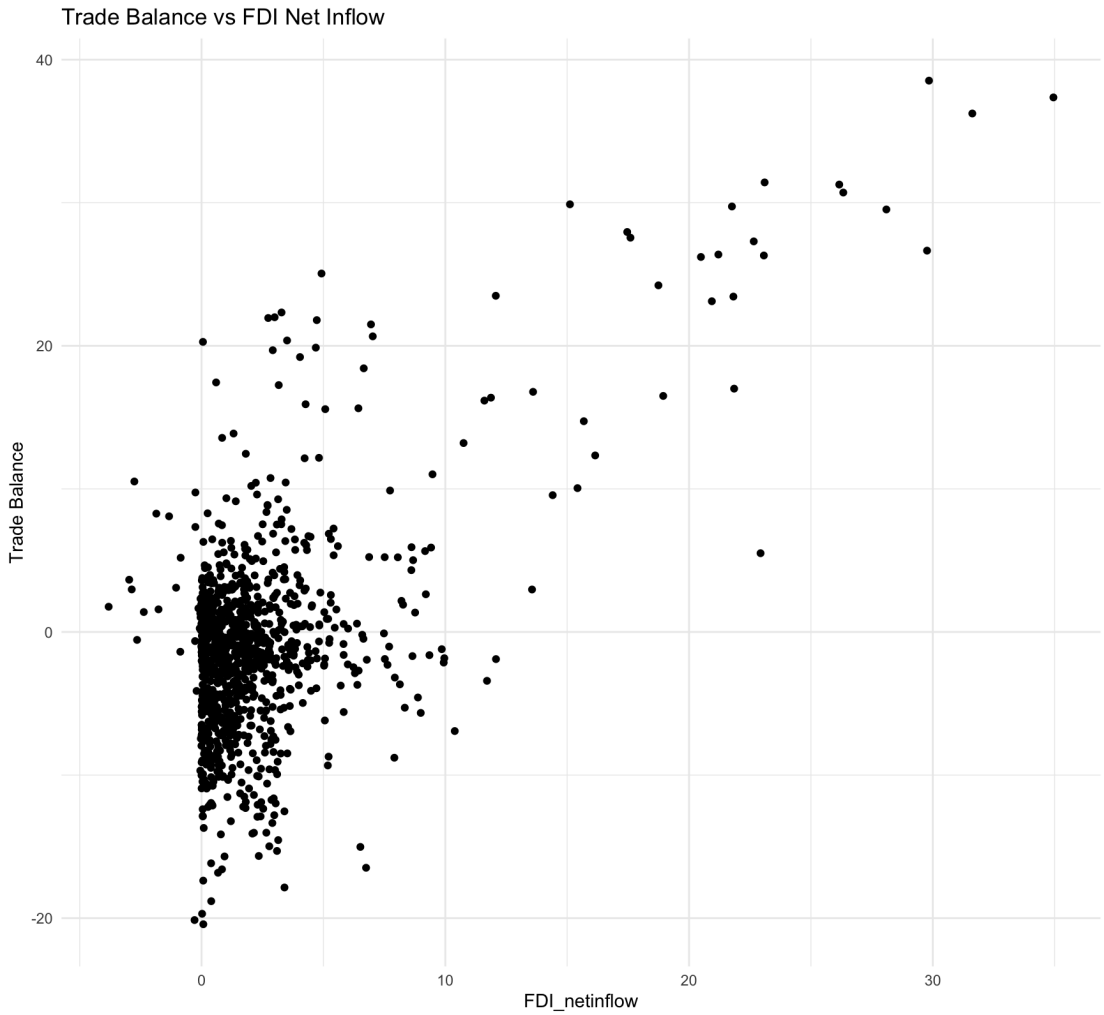

Figure 4: Scatter plot of TB vs FDI_NI

The scatterplot from Figure 4 visualizes the relationship between Trade Balance and FDI inflow. From the visualization, one can observe that most data points are concentrated near lower FDI net values, suggesting that FDI inflows do not correspond to a higher or lower trade balance. However, a positive correlation show between trade balance and FDI net inflow, meaning that some countries might have improvement in trade balance when they receive FDI inflows. This highlights the importance of foreign development investment in improving trade balance.

Figure 5: Scatterplot of TB vs FDI_NO

The scatterplot from Figure 5 visualizes the relationship between Trade balance and FDI outflows. One can find that most data points are concentrated near lower FDI net values, suggesting that FDI outflows do not correspond to a higher or lower trade balance. However, a positive correlation can be seen between trade balance and FDI net outflows, meaning that some countries might have improvement in trade balance when they invest in other countries. In addition to that, there are some data points of trade balance in negative value suggesting that FDI net outflow can cause a negative impact on trade balance such as dependence on foreign products and many more. This underscores the importance of foreign development investment in improving trade balance, but policymakers need to be wary as it could also lead to more imports than exports, leading to the trade deficit.

2.4. Hypothesis

To understand the impact of exchange rate, inflation, and FDI, the following hypotheses were tested to investigate the objectives of this report.

A. *Hypothesis (H_1):* The exchange rate has a significant impact on lower and upper-middle-income countries.
Null Hypothesis (H_0): The exchange rate has no impact on lower and upper-middle-income countries.

$$TB_{it} = \beta_0 + \beta_1(ER_{it}) + \beta_2(ER_{it} * IG_{it}) + \alpha_i + \epsilon_{it}$$

Where, β_0 = Intercept, TB = Trade Balance, ER = Exchange Rate, IG = Income Group, i = Country, t = Time, α_i = Country-specific fixed effects, ϵ_{it} = Error term (random disturbance)

B. *Hypothesis (H_2)*: Inflation negatively affects the trade balance across income groups.
Null Hypothesis (H_0): Inflation has no effects on the trade balance across income groups.

$$TB_{it} = \beta_0 + \beta_1(IF_{it}) + \beta_2(IF_{it} * IG_{it}) + \alpha_i + \epsilon_{it}$$

Where, β_0 = Intercept, TB = Trade Balance, IF = Inflation, IG = Income Group, i = Country, t = Time, α_i = Country & time -specific fixed effects, ϵ_{it} = Error term (random disturbance)

C. *Hypothesis (H_3):* FDI inflows and outflows have a positive impact on the trade balance of high, lower, and middle-income countries.
Null Hypothesis (H_0): FDI inflows and outflows have no impact on the trade balance across all income groups.

$$TB_{it} = \beta_0 + \beta_1(FDI\_NI_{it}) + \beta_2(FDI\_NF_{it} * IG_{it}) + \beta_4(FDI\_NO_{it}) + \beta_4(FDI\_OF_{it} * IG_{it}) + \alpha_i + \epsilon_i$$

Where, β_0 = Intercept, TB = Trade Balance, FDI_NF = Net inflow, FDI_OF = Net outflow, IG = Income Group, i = Country, t = Time, α_i = Country & time -specific fixed effects, ϵ_{it} = Error term (random disturbance)

2.5. Methodology

The following three fixed effects models were used to investigate the research objectives of this report.

$$TBit = \beta0 + \beta1(ERit) + \beta2(ERit * IGit) + \alpha i + \epsilon it$$

$$TBit = \beta0 + \beta1(IFit) + \beta2(IFit * IGit) + \alpha i + \epsilon it$$

$$TB_{it} = \beta_0 + \beta_1(FDI\_NI_{it}) + \beta_2(FDI\_NF_{it} * IG_{it}) + \beta_4(FDI\_NO_{it}) + \beta_4(FDI\_OF_{it} * IG_{it}) + \alpha_i + \epsilon_i$$

The next sections explain the results of the data analysis, providing the answers to these questions and giving recommendations.

3. Data Analysis and Findings

3.1. Descriptive Statistics

The table below summarizes key descriptive statistics for exchange rates, inflation, foreign direct investment (FDI), exports, and imports. It provides key insights into the economic variables. The exchange rate data reveals a highly skewed data distribution as there is a huge difference between the mean and median. Inflation seems to have a lot of variation, suggesting that some countries have faced extreme hyperinflation, and some have faced deflation. The FDI inflow trend shows that many countries have attracted capital inflows, but at the same time, there are many countries that struggle

with FDI outflows. From the descriptive statistics, it can be observed that most of the countries tend to operate at trade deficits as the imports exceed the exports.

	N	*Mean*	*Median*	*Min*	*Max*
ER	1050	1.243e+09	0.000e+00	1.000e+00	3.401e+11
IF	1050	20.413	5.903	-17.630	2736.971
IM	1050	35.032	27.317	5.461	208.931
EX	1050	34.148	25.285	2.895	228.994
FDI_NO	1050	1.35061	0.33170	-7.86883	22.59415
FDI_NI	1050	2.3802	1.3605	-3.8118	34.9485

Table 3: Descriptive Statistics

3.2. Correlation Results

Using R/RStudio, Pearson's correlation matrix was created, as shown in Table 4 below. This matrix shows the level of association between all variables. The value ranges from -1 to +1; the closer the value is to 1, the more two variables correlate to each other. The variables exchange rate and inflation show no correlation with the dependent variable trade balance. On the other hand, the variables FDI net inflow and FDI net outflow have 0.5881 and 0.5799 correlation values, indicating a moderate relationship with trade balance. This makes sense since FDI increases imports of products and increases the productivity of the country overall.

	TB	*ER*	*IN*	*FDI_NI*	*FDI_NO*
TB	1				
ER	0.010	1			
IF	0.0193	0.2333	1		
FDI_NI	0.5881	-0.0618	-0.0558	1	
FDI_NO	0.5799	-0.0570	-0.0570	0.7324	1

Table 4: Correlation matrix

3.3. Regression Results

In this section, the results of the regression models for each hypothesis are explained. All regression models were conducted in R.

Hypothesis (H_1): The exchange rate has a significant impact on lower and middle-income countries.

In this hypothesis, the key concept is to understand how the exchange rate affects the trade balance in lower- and middle-income countries. A one-way fixed effect was used to analyze the data. The data was converted to panel data where country and time were taken as controlled variables. The model accounts for country-specific factors that influence trade balance. They provide significant insights.

$$TBit = \beta 0 + \beta 1(ERit) + \beta 2(ERit * IGit) + \alpha_i + \epsilon it$$

where the symbol i denotes the country observed, t denotes the time, and β_0 is the intercept.

```
Coefficients:
                                 Estimate Std. Error t-value  Pr(>|t|)
ER                               -2.77915    0.60904 -4.5631 5.977e-06 ***
ER:IGLow Middle Asia            -12.62276    3.82527 -3.2998  0.001018 **
ER:IGUpper Middle Asia            2.66251    0.61231  4.3483 1.581e-05 ***
ER:IGUpper Middle Latin America   2.78134    0.60952  4.5632 5.976e-06 ***
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Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
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N	*F-statistic*	*p-value*	*R-squared*	*Adj R-squared*
700	*10.2197*	*4.8563e-08*	*0.05655*	*0.033033*

Table 5: Fixed effects regression results for Hypothesis 1

From Table 3, one can find a significant negative relation between the exchange rate and the trade balance, which is reflected by the coefficient estimates -2.78.and $p < 0.001$. A depreciation in the exchange rate generally negatively affects the trade balance when not interacting with any of the income group variables. However, when the exchange rate interacts with specific income groups, it has a positive effect on the trade balance of Upper Middle Asia and Upper Middle Latin America. The coefficient estimates for Upper Middle Asia is 2.66 and Upper Middle Latin America is 2.78; both variables are statistically significant with $p<0.001$. On the other hand, in Lower Middle-Income Asia, the exchange rate has a negative effect, suggesting that exchange rate deteriorates the trade balance this is reflected by the coefficient estimates -12.63 and is statistically significant $p < 0.05$. Overall, the exchange rate has a negative effect, but it varies by region and income group. In low-middle Asia, the negative effect is significant, while in upper-middle Asia and Latin America, the effect is positive (less negative). Therefore, the hypothesis that exchange rates have a significant impact on trade balance is supported.

For model diagnostics, the F-statistic is 10.22 (p-value < 0.001), suggesting that the model is statistically significant. It means that the model is meaningful in explaining some variations in the trade balance. However, the R-squared is 0.057, which means that only 5.7% variance in the trade balance is explained by the model. This could mean that the exchange rate itself is not enough and needs additional explanatory variables, such as inflation, trade policies, and interest rates for a more rigorous analysis.

Hypothesis (H_2): Inflation negatively affects the trade balance in lower, middle and high-income countries.

In this hypothesis, the key concept is to check if inflation is inversely proportional to trade balance. A two-way time-effects model was used to create the model. The data is converted to panel data, and country and time are taken as controlled variables. The model accounts for country-specific factors that influence trade balance. They provide significant insights.

$$TBit = \beta 0 + \beta 1(IFit) + \beta 2(IFit * IGit) + \alpha i + \epsilon it$$

where the symbol i denotes the country observed, t denotes the time, and $\beta_{0\ is}$ the intercept.

```
Coefficients:
                                Estimate Std. Error t-value  Pr(>|t|)
IF                              -0.68490    1.64567 -0.4162 0.6773680
IF:IGHigh Income Europe Na       7.19990    2.14106  3.3628 0.0008017 ***
IF:IGLow Middle Africa Mena      3.56200    1.92914  1.8464 0.0651342 .
IF:IGLow Middle Asia             2.16291    1.74386  1.2403 0.2151639
IF:IGUpper Middle Asia           1.36265    1.67543  0.8133 0.4162354
IF:IGUpper Middle Latin America  0.71621    1.64578  0.4352 0.6635265
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

N	*F-statistic*	*p-value*	*R-squared*	*Adj R-squared*
1050	*5.47011*	*1.4006e-05*	*0.032598*	*-0.041894*

Table 6: Fixed effects regression results for Hypothesis 2

From Table 4, one can find a significant negative relation between the inflation and the trade balance, reflected by the coefficient estimates -6.59, but the variable is not significant because the p-value is 0.677. The model suggests that inflation alone may not have a direct effect on trade balance after taking country and time effects into account. The initial expectation was that rising inflation would deteriorate the trade balance, which holds true, but it is not statistically significant. However, the interaction terms with different income groups show different results. The interaction term of inflation with income group high-income Europe Na has a coefficient estimate of 7.199, with a p-value of 0.0008, meaning that it is highly significant. This could be because high-income European countries are less affected by inflation due to their strong policies, strong exchange rates, and high value-added exports that are not price sensitive. The model also suggests that inflation in Lower and Upper middle-income countries might have a positive effect, but the evidence is not strong enough to prove that. This contradicts our hypothesis that inflation would negatively affect the trade balance in these countries. Therefore, our hypothesis is not fully supported. This could be due to devaluation in currency, which improves export competitiveness.

For model diagnostics, the F-statistic is 5.471 (p-value = 1.4006e-05), suggesting that the model is statistically significant. It means that the model is meaningful in explaining some variations in the trade balance. The R-squared is 0.03, meaning that only about 3% of the variance in the trade balance is explained by the model. This could mean the model might need additional explanatory variables, such as inflation, trade policies, and interest rates, for a more rigorous analysis.

Hypothesis (H_3): FDI inflows and outflows have a positive impact on the trade balance of high-income, low- and middle-income countries.

In this hypothesis, the key concept is to understand how FDI affects the trade balance across different income groups. A two-way fixed effects model was used to create the model. The data is converted to panel data, and country and time are taken as controlled variables. Table 4 below presents the results.

$$TB_{it} = \beta_0 + \beta_1(FDI\_NI_{it}) + \beta_2(FDI\_NF_{it} * IG_{it}) + \beta_4(FDI\_NO_{it}) + \beta_4(FDI\_OF_{it} * IG_{it)} + \alpha_i + \epsilon_i$$

where the symbol i denotes the country observed, t denotes the time, and β_0 is the intercept.

```
Coefficients:
                                    Estimate Std. Error t-value  Pr(>|t|)
FDI_NI                              0.140158   0.046376  3.0222 0.0025755 **
FDI_NO                              0.546911   0.052869 10.3447 < 2.2e-16 ***
FDI_NI:IGHigh Income Europe Na     -0.213173   0.065699 -3.2447 0.0012160 **
FDI_NI:IGLow Middle Africa Mena    -1.165269   0.644115 -1.8091 0.0707455 .
FDI_NI:IGLow Middle Asia            0.338461   0.288658  1.1725 0.2412714
FDI_NI:IGUpper Middle Asia          0.530156   0.103654  5.1147 3.789e-07 ***
FDI_NI:IGUpper Middle Latin America 0.407649   0.285565  1.4275 0.1537535
IGHigh Income Europe Na:FDI_NO     -0.555393   0.088654 -6.2648 5.610e-10 ***
IGLow Middle Africa Mena:FDI_NO    -0.515964   0.135280 -3.8140 0.0001454 ***
IGLow Middle Asia:FDI_NO           -1.276796   0.230539 -5.5383 3.935e-08 ***
IGUpper Middle Asia:FDI_NO         -0.976890   0.119649 -8.1647 9.985e-16 ***
IGUpper Middle Latin America:FDI_NO -0.973869   0.149142 -6.5298 1.061e-10 ***
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Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

N	*F-statistic*	*p-value*	*R-squared*	*Adj R-squared*
1050	*40.2553*	*<2.22e-16*	*0.3329*	*0.27708*

Table 7: Fixed effects regression for Hypothesis 3

From Table 5, one can find a positive and significant effect on the trade balance, reflected by the coefficient estimates 0.14 and p-value 0.002. This result aligns with the expectations, as FDI inflows are expected to improve a country’s trade balance. However, the interaction terms show different results. In the High-income Europe Na region, FDI net inflows appear to negatively affect the trade balance, reflected by a coefficient estimate of -0.21 with a p-value of 0.001; this contradicts our hypothesis. This shows that the effects of FDI on trade balance are different across regions. On the other hand, Upper Middle Asia is positively affected by the FDI net inflow reflected by coefficient estimates of 0.530 and a p-value of 3.789e-07. For other income groups and regions, FDI net inflows have a positive but statically insignificant effect on trade balance. This means that FDI inflows might help improve the trade balance, but the evidence is not strong enough to confirm it.

Regarding FDI outflow, one can find a significant positive relation between FDI net outflow and the trade balance, reflected by 0.546 and p-value < 2.2e-16. This means that increased outward investment generally improves the trade balance. However, the interaction term with the income groups suggests otherwise. It shows that FDI net outflows have a negative impact on all income groups across all regions, with the results being statistically significant. The results do not fully support the hypothesis that FDI outflows positively affect high-income countries and negatively affect low-income countries. This could be because the foreign direct investment increases dependency on imported goods and services, which could possibly lead to the dependency on imported products due to the foreign investment from other countries.

For model diagnostics, the F-statistic is 40.2553 (p-value = < 2.22e-16), suggesting that the model is statistically significant. It means that the model is meaningful in explaining some variations in the trade balance but leaves a substantial portion unexplained. The R-squared is 0.33, meaning that only about 33% of the variance in the trade balance is explained by the mode.

4. Limitations

This paper studies the impact of the macroeconomic variables on trade balance across multiple countries and income groups, but there are a few limitations to this study. Due to the limited availability of data points, a broader approach and research were taken, which has led to some inconsistent results. Instead of yearly data points, focusing on more granular monthly data points could help yield better results and allow for more rigorous analysis.

Another key limitation of this study is the presence of autocorrelation in some data points, which means past errors influence future errors. This could be due to some missing values that were imputed based on the historical trends, which may have introduced bias into the results. This has probably led to some potential errors. To assess this, Durbin-Watson statistics was applied to check the availability of autocorrelation in each model (references). It can be observed that the D-W statistics are less than ~ 2, which suggests the presence of positive autocorrelation; this means that the dataset may contain some dependencies from the past variables that could affect the reliability of the findings.

Despite having these limitations, the study does provide intricate insights on the relationship between exchange rate, inflation, FDI, and trade balance that is insightful and helpful for IDS. For future research, these constraints could be addressed by incorporating more granular data, which explores advanced econometric models.

5. Conclusions and Recommendations

This paper has explored the complex and intricate relationships between exchange rates, inflation, foreign direct investment (FDI), and trade balances across income groups. The findings from this study have been both interesting and unexpected at the same time, which indicates that it requires further research and refinements. Since the study shows complex and non-linear relationships, machine learning models such as ARIMA (Autoregressive Integrated Moving Average) and neural networks can be used to make this study more useful in the context of the real world. This model can help predict the long-term effects of macroeconomic factors on trade balance. Although there are a couple of traditional econometric models present in the economic industry, those models do not fully capture the intricate relationships between the variables. The integration of new technologies, such as machine learning models, has the potential to reveal patterns at a more nuanced level and offer more accurate predictions. Furthermore, to make this study more solid, further investigation could be conducted to test the Marshall-Lerner condition, which suggests that the depreciation value of the exchange rate affects trade balance positively in the long-term. This condition has been studied by many economists but not in comparison of income groups. This could particularly provide insights on whether this condition is true for lower- and middle-income groups or if it holds true for all income groups.

In short, the study of this paper helps to scratch the surface of trade balance by allowing us to understand how exchange rates, inflation, and FDI impact trade balances across different income groups. While the initial hypothesis was to understand the impact of exchange rate, inflation, and foreign impacting on the trade balance, the empirical findings from this project presented significant variations across different income groups. Similarly, the results on inflation suggest a negative overall relationship with trade balance, which were the expected results. The paper also explores the relationship between FDI and trade balance, The findings show a positive relationship between FDI inflows and trade balance, which supports the hypothesis that FDI can have positive effects on trade balance. Further research can help refine these findings to create advanced predictive models. Doing this will help IDS to provide effective tailored strategies to countries of different economic contexts.

6. Bibliography

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Appendix

```
# 1. Effect of Exchange Rate on Trade Balance
#Hypothesis 1

# Filter data to include only low- and middle-income countries
panel_data_low_middle <- panel_data %>%
  filter(IG %in% c("Low Middle Asia", "Low Middle Africa Mena", "Upper Middle Asia", "Upper Middle Latin America"))

#Fixed Effects Model
fe_model_1 <- plm(TB ~ ER * IG,
                  data = panel_data_low_middle,
                  index = c("Country.Name", "Time"),
                  model = "within", effect = "individual")
summary(fe_model_1)

#Convert to OLS Model for Diagnostics
ols_model_1 <- lm(Net_Balance ~ USD_per_LCU * IG + as.factor(Country.Name),
                              data = panel_data_low_middle)

# Durbin-Watson Test for Autocorrelation
dw_test_1 <- durbinWatsonTest(ols_model_1)  # Run on OLS model
print(dw_test_1)

#Variance Inflation Factor (VIF) for Multicollinearity
vif_values_1 <- vif(lm(Net_Balance ~ USD_per_LCU * IG,
                    data = panel_data_low_middle), type = "predictor")  # Run on OLS model
print(vif_values_1)
```

Appendix 1: Hypothesis 1

```
#2. Effect of Inflation on Trade Balance
#Hypothesis 2

# Fixed Effects Model for Inflation Impact on Trade Balance
fe_model_2 <- plm(TB ~ IF * IG,
                  data = panel_data,
                  index = c("Country.Name", "Time"),
                  model = "within", effect = "individual")

summary(fe_model_2)

#Convert to OLS Model for Diagnostics
ols_model_2 <- lm(Net_Balance ~ Inflation * IG,
                data = panel_data)

# Durbin-Watson Test for Autocorrelation
dw_test_2 <- durbinWatsonTest(ols_model_2)  # Run on OLS model
print(dw_test_2)

#Variance Inflation Factor (VIF) for Multicollinearity
vif_values_2 <- vif(lm(Net_Balance ~ Inflation * IG,
                    data = panel_data), type = "predictor")  # Run on OLS model
print(vif_values_2)
```

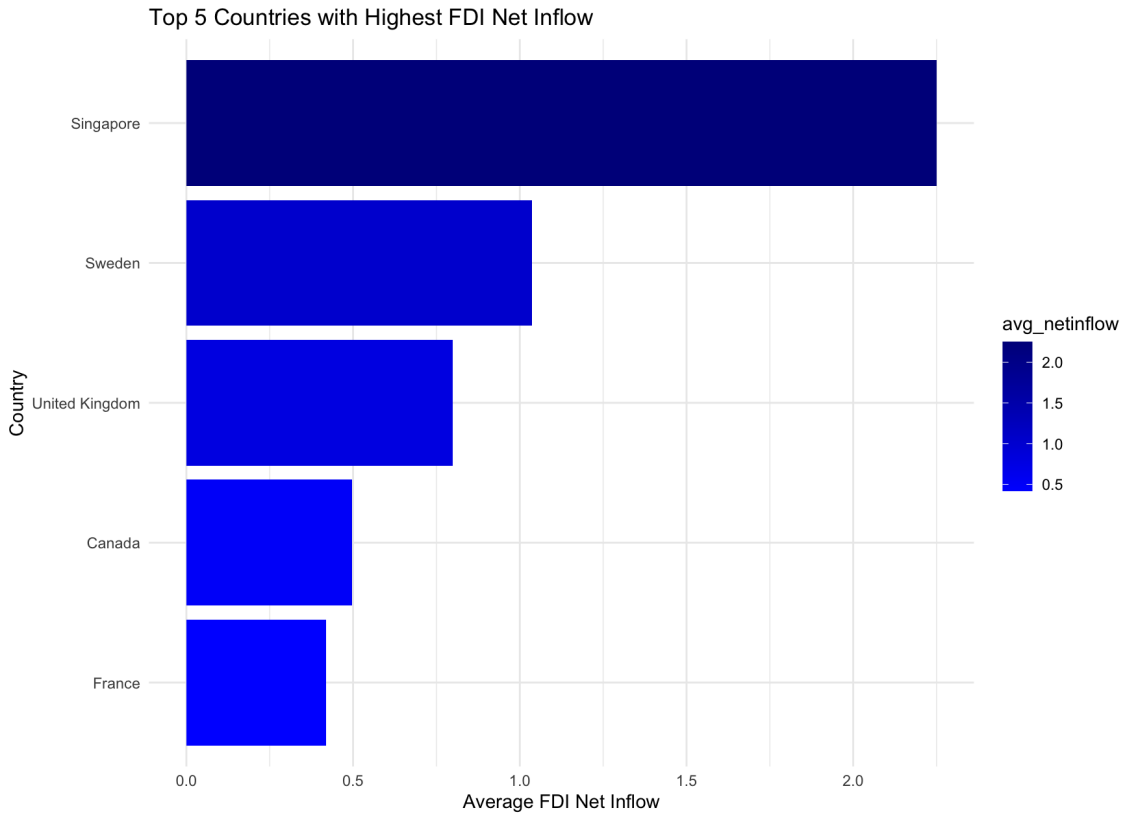
Appendix 2: Hypothesis 2

```r
#3. Effect of FDI on Trade Balance
#Hypothesis 3
fe_model_3 <- plm(TB ~ FDI_NI * IG + FDI_NO * IG,
                  data = panel_data,
                  index = c("Country.Name", "Time"),
                  model = "within", effect = "individual")

summary(fe_model_3)

#Convert to OLS Model for Diagnostics
ols_model_3 <- lm(Net_Balance ~ FDI_netinflow * IG + FDI_netoutflow * IG,
                  data = panel_data)

# Durbin-Watson Test for Autocorrelation
dw_test_3 <- durbinWatsonTest(ols_model_3)  # Run on OLS model
print(dw_test_3)

#Variance Inflation Factor (VIF) for Multicollinearity
vif_values_3 <- vif(lm(Net_Balance ~ FDI_netinflow * IG + FDI_netoutflow * IG,
                       data = panel_data), type = "predictor")  # Run on OLS model
print(vif_values_3)
```

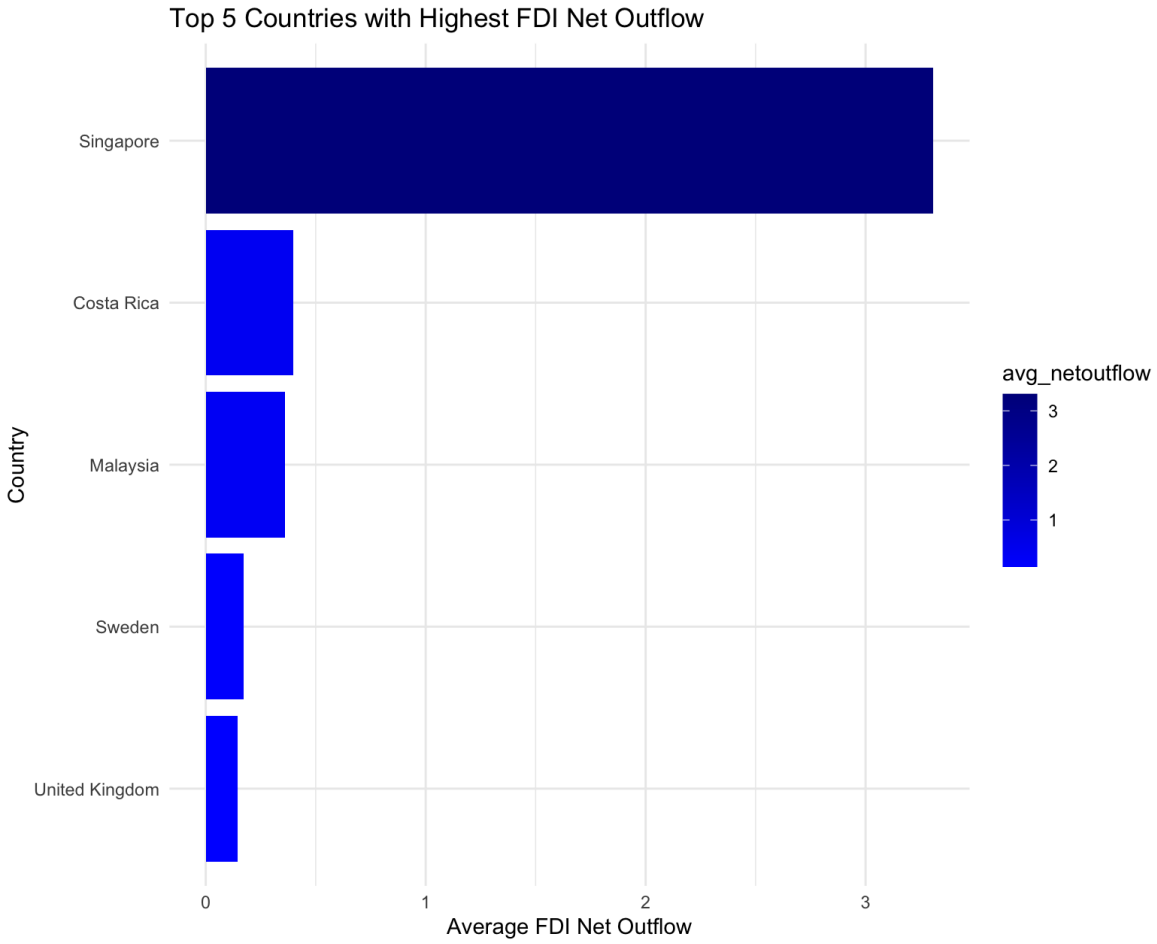
Appendix 3: Hypothesis 3

```
 lag Autocorrelation D-W Statistic p-value
   1       0.7465967     0.5059443       0
 Alternative hypothesis: rho != 0
```

Appendix 4: Durbin Watson statistics



Appendix 5: Top 5 Countries with Highest FDI Net Inflow



Appendix 6: Top 5 Countries with Highest FDI Net Outflow