Analyzing the impact of trade on Economic growth Using the ARDL model in Stata

1.1 Data description and Variables

To analyze the impact of trade on economic growth in Latin America and the Caribbean covering the period from 1990 to 2023 for a total of 20 nations, panel data was applied. The control variables are Interest rate, Wages, Education, FDI, Inflation, Population. The main source of the data in this study is available from the World Bank's World Development Indicators (WDI), UNCTADStat, International Monetary Fund (IMF) World Economic Outlook (WEO), International Labour Organization (ILO) Statistics (ILOSTAT), IMF Coordinated Direct Investment Survey (CDIS). To address missing values in the data, the linear interpolation method was conducted as well as using forward fill and back fill techniques.

The Latin America and the Caribbean (LAC) region consists of 33 sovereign independent countries. Subregions emerge from the division of these areas according to geographical boundaries and common cultural or linguistic traits. Latin America is divided between: The South American subregion contains 12 nations (Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Guyana, Paraguay, Peru, Suriname, Uruguay, Venezuela) while Central America comprises 7 countries (Belize, Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua, Panama, Mexico). There are 13 countries in the Caribbean region which include Antigua and Barbuda, The Bahamas, Barbados, Cuba, Dominica,

Dominican Republic, Grenada, Haiti, Jamaica, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, Trinidad and Tobago. The countries belong to the United Nations (UN), International Monetary Fund (IMF), World Trade Organization (WTO) and World Bank Group. Our study only focused on the following countries: The study examined panel data from 20 countries across Latin America and the Caribbean namely Argentina, Bolivia, Brazil, Chile, Colombia, Paraguay, Peru, Suriname, Uruguay, Venezuela, Belize, Costa-Rica, Guatemala, Honduras, Nicaragua, Panama, Dominican-Republic, Haiti, Jamaica, Mexico. Due to data availability, the following countries were dropped from the sample: Antigua and Barbuda, Barbados, Cuba, Dominica, Grenada, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, El Salvador, Trinidad and Tobago, Ecuador. Therefore, the study analyzed panel data from a total of 20 Latin American and Caribbean countries spanning from 1990 to 2023.

1.2 Descriptive Statistics

Descriptive statistics for all variables appear in Table 4.1 Based on Table 4.1, there are 660 observations for each and every variable.

Table 1.1 Descriptive Statistics

Descriptive Statistics

Variable		Mean	Std. dev	Min	Max	Obs
Gdp	overall	3.27298	0.13552	2.95708	3.49200	660
	between		0.04866	3.16907	3.35909	
	within		0.12694	2.87097	3.59591	
Trade	overall	4.11645	0.44323	3.30186	5.06888	660

	between		0.41824	3.35498	4.81647	
	within		0.17327	3.39213	4.58325	
Unempl	overall	2.03827	0.40232	1.29855	2.74451	660
	between		0.35133	1.33574	2.52371	
	within		0.21076	1.52675	2.83497	
Wages	overall	58.57941	14.12258	23.37960	83.38158	660
	between		14.20730	24.31262	79.59070	
	within		2.72053	49.51188	68.22310	
Intr r	overall	8.49335	12.12812	-16.53998	35.53009	660
	between		9.24982	-7.28637	32.51906	
	within		8.10474	-18.50594	42.53663	
FDI	overall	2.59940	0.16818	2.34840	2.94809	660
	between		0.10741	2.39081	2.78183	
	within		0.13156	2.16597	3.00585	
Infl	overall	3.65531	0.27164	3.34167	4.39571	660
	between		0.16117	3.40956	4.09408	
	within		0.22152	3.10146	4.47645	
Pop	overall	62.25983	4.13456	53.86251	68.96037	660
	between		2.88917	56.69023	66.92620	
	within		3.02534	55.20385	70.60114	

Edu	overall	3.42474	0.45613	2.4598	2.45980	660
	between		0.40977	2.49251	3.99928	
	within		0.21977	3.01161	4.23003	

Source: Author's calculation

The descriptive statistics for the dataset, covering 660 observations across 20 countries over 33 years, reveal significant economic heterogeneity. The average GDP growth rate is 3.27%, with a low overall standard deviation of 0.1355, indicating relatively stable economic growth patterns across time and countries. The decomposition shows a between-country standard deviation of 0.0486, suggesting that structural differences in economic growth between countries are small, while the within-country standard deviation of 0.1269 implies greater fluctuations in growth over time within individual nations. Trade, as a percentage of GDP, has a mean of 4.12%, with higher between-country variation (0.4182) than within-country variation (0.1732), indicating that some economies are more trade-dependent than others, but trade remains relatively stable over time within each nation. Wage levels exhibit a broad range, from 23.38 to 83.38, with an overall standard deviation of 14.12, reflecting significant income disparities. Similarly, the interest rate varies dramatically, with values spanning from -16.53 to 35.53, and an overall standard deviation of 12.13, highlighting vast differences in monetary policies and financial conditions across countries. Foreign direct investment (FDI) as a percentage of GDP shows a narrow range (2.35 to 2.95), with low variation (0.1681 overall standard deviation), suggesting that FDI inflows are relatively stable across countries and time. Inflation levels, averaging 3.65%, display moderate variability (0.2716 overall standard deviation), indicating price stability

in some nations but volatility in others. Unemployment rates range from 1.29% to 2.74%, with a between-country standard deviation of 0.3513, suggesting structural labor market differences across economies. Population demographics and education levels also exhibit moderate variation, with higher between-country standard deviations (2.8892 and 0.4097, respectively), indicating that some nations have significantly higher education levels and different population structures. These findings highlight key economic disparities across countries, emphasizing the need for tailored policy interventions. Countries with high unemployment and low FDI inflows should focus on attracting investment and improving labor market efficiency, while those with volatile inflation and interest rates may require stronger monetary policies. Given the significant between-country differences in trade and wage levels, policymakers should consider enhancing trade openness and labor market reforms to reduce disparities. Overall, the dataset reveals substantial economic diversity, warranting further econometric analysis to explore causal relationships and policy implications. These findings suggest that when examining the relationship between employment, trade, and economic growth, it is crucial to account for the different sources of variation. Indicators with high within-country variation, such as GDP growth and inflation, may be more suitable for time-series analysis, while those with high between-country variation, such as wages and education, provide stronger cross-sectional insights into structural economic differences.

1.3 Correlation Coefficient

In this study the Pearson's correlation was employed to understand the relationships between variables and identifying potential multicollinearity issues. Multicollinearity occurs when two or more independent variables are highly correlated. This can distort

regression results. The correlation matrix provides insights into the relationships between key economic variables in the dataset. Correlation values range from -1 to 1.

Table 1.2 Correlation Matrix (660 obs)

Matrix of correlations

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(1) gdp	1.0000								
(2) trade	0.1646	1.000							
(3) wages	0.0252	0.1793	1.0000						
(4) interest rate	0.1259	-0.1244	-0.1549	1.0000					
(5) fdi	0.2420	0.3339	0.1870	0.0907	1.0000				
(6) inflation	-0.2081	-0.2239	0.0795	-0.3263	-0.3960	1.0000			
(7) population	-0.0771	-0.0953	0.4499	-0.0806	0.2444	-0.1592	1.0000		
(8) education	-0.0198	-0.0375	0.2994	0.0419	0.3124	-0.1575	0.6612	1.0000	
(9) unempl	-0.1984	-0.2361	0.2462	-0.0953	-0.0853	0.1472	0.2948	0.0028	1.0000

Source: Author's calculation

Table 4.2 shows that Trade (0.1646): Weak positive correlation, suggesting that higher trade levels tend to be associated with slightly higher GDP growth. However, the relationship is not very strong. Wages (0.0252): Very weak positive correlation, implying that changes in wage levels do not strongly affect GDP growth. Interest Rate (0.1259): Weak positive correlation, indicating that higher interest rates might have a small effect on economic growth. FDI (0.2420): Moderate positive correlation, showing that an increase in foreign direct investment is associated with higher GDP growth, reinforcing the importance of attracting investment for economic expansion. Inflation (-0.2081): Weak negative correlation, meaning that higher inflation is slightly associated with lower GDP growth, which aligns with economic theories suggesting that excessive inflation can reduce economic performance. Population (-0.0771): Very weak negative correlation, suggesting that population dynamics do not strongly affect GDP growth in this dataset. Education (-

0.0198): Almost no correlation, meaning that higher education levels do not show a clear relationship with GDP growth in this analysis. Unemployment (-0.1984): Weak negative correlation, indicating that higher unemployment rates are slightly associated with lower GDP growth, which is expected as unemployment generally reduces economic productivity. Overall, these findings highlight the interconnected nature of economic variables, where trade, education, and population size appear to support economic growth, while inflation and unemployment may pose constraints. However, the relatively weak correlations across most indicators suggest that economic performance is influenced by multiple factors beyond those captured in this dataset.

1.4 Panel Unit root

Conducting a unit root test is essential in the ARDL model to determine the stationarity of variables, ensuring valid estimation and meaningful relationships. The ARDL framework accommodates a mix of I(0) and I(1) variables but becomes invalid if any variable is I(2), as the F-statistics for bounds testing are no longer applicable. Checking for unit roots helps prevent spurious regression, where non-stationary variables produce misleading results. Moreover, it ensures appropriate lag selection and model specification, capturing the true dynamics of the data. Since ARDL is designed to test long-run relationships through cointegration analysis, confirming the integration order of variables is crucial. Common unit root tests, such as the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests, help verify these properties. If a variable is I(2), it must be excluded or transformed before proceeding with ARDL estimation.

Table 1.3 Results of Panel Unit Root Test

Variable	P- value	First differencing
gdp	0.0000	0.0000
trade	0.0023	0.0023
wages	0.5344	0.0000
Interest rate	0.0000	0.0000
fdi	0.0000	0.0000
inflation	0.0000	0.0000
population	0.0000	0.0000
education	0.0214	0.0214
unemployment	0.0009	0.0009

Source: Author's calculation

Table 4.3 shows the results of Panel Unit Root Test. The results indicate that most variables in the dataset are stationary, while only wages exhibit non-stationarity the null hypothesis was not rejected with a p-value of 0.5344. Therefore, the first Differencing was applied to the wages variable to make sure it becomes stationary. After first differencing there are 22 missing values which is to be expected because first differencing removes one observation per country. ARDL/PMG regressions in Stata automatically excludes missing values, so

they don’t need to be manually dropped. The null hypothesis of a unit root is rejected for GDP (p = 0.0000), trade (p = 0.0023), interest rate (p = 0.0000), FDI (p = 0.0000), inflation (p = 0.0000), population (p = 0.0000), education (p = 0.0214), and unemployment (p = 0.0009), confirming that these variables are stationary at level I(0). Since the ARDL model requires a mix of I(0) and I(1) variables.

1.5 Panel Cointegraion Test

The Kao test for cointegration is a residual-based panel data approach that assesses whether a long-run equilibrium relationship exists among integrated variables across cross-sectional units. Developed as an extension of the Engle-Granger two-step method, the Kao test assumes homogeneity in the cointegrating vector across entities and imposes common autoregressive parameters under the null hypothesis of no cointegration. This test includes several variants—such as the Modified Dickey–Fuller t, Dickey–Fuller t, and Augmented Dickey–Fuller t statistics—that correct for serial correlation and endogeneity in the residuals. The modified versions of these statistics further enhance robustness by adjusting for heteroskedasticity and serial correlation in the error terms. The unadjusted forms, while simpler, serve as a useful baseline comparison. When any of these test statistics yield a significantly negative value, it provides evidence to reject the null hypothesis of no cointegration, indicating that the variables share a common stochastic trend and are linked in the long run. The Kao test is particularly suited for balanced panel datasets and complements other cointegration tests by offering a straightforward and efficient approach for validating long-run relationships in macroeconomic and financial panel data settings.

Table 1.4 Kao test for cointegration

	Coef.	P-value
Dickey–Fuller t	181.2253	0.0000
Modified Dickey–Fuller t	12.3356	0.0000
Augmented Dickey–Fuller t	63,900	0.0000
Unadjusted modified Dickey–Fuller t	-31.1148	0.0000
Unadjusted Dickey–Fuller t	-17.1787	0.0000

Source: Author's calculation

The Kao panel cointegration test was conducted to examine the presence of a long-run equilibrium relationship among the variables, with the null hypothesis (H_0) positing no cointegration. The test assumes a common cointegrating vector across panels, includes panel-specific means, and excludes a time trend, the analysis spans 20 panels over 31 time periods. All test statistics overwhelmingly reject the null hypothesis at the 5% significance: the modified Dickey-Fuller t-statistic (-12.3356, p = 0.000), Dickey-Fuller t-statistic (-12.9477, p = 0.000), and augmented Dickey-Fuller t-statistic (-8.7160, p = 0.000) uniformly confirm cointegration. The unadjusted statistics further reinforce this conclusion (unadjusted modified Dickey-Fuller t = -31.1148, p = 0.000; unadjusted Dickey-Fuller t = -17.1787, p = 0.000). These results provide strong evidence that the variables share a stable long-run relationship,

Given this result, it would be more appropriate to use a panel error correction model (ECM) or ARDL model. The absence of a time trend in the cointegrating equation suggests that the equilibrium relationship is driven by the variables themselves rather than exogenous

trends. Policymakers can rely on these findings to design long-term strategies, as shocks to the system will eventually revert to this equilibrium.

1.6 Muticollinearity test (VIF)

The Variance Inflation Factor (VIF) The variance inflation (inflating) factor (VIF) is often used to test the extent of multicollinearity in regression models, which occurs when independent variables exhibit high correlation. It is defined as: $\mathrm{VIF_k} = \frac{1}{1-\mathrm{R_k^2}}$ where R_k^2 is the $\mathrm{R^2}$ in the regression of $\mathrm{X_k}$ on all the other independent variables Greene (2003). Multicollinearity can significantly impact the reliability of regression estimates by distorting coefficient values, inflating standard errors, and reducing the statistical significance of explanatory variables. Additionally, it can cause instability in the model, where small changes in data lead to substantial variations in regression outcomes. To further assess multicollinearity, the reciprocal of VIF, known as 1/VIF (Tolerance), is also examined. Tolerance measures the proportion of a variable's variance that is not explained by other independent variables. A low 1/VIF value (close to 0) indicates a high degree of collinearity, suggesting that the variable shares a substantial amount of variance with others in the model.

Table 1.5 Multicollinearity test (VIF)

Variance inflation factor

	VIF	1/VIF
population	2.23	0.447642
education	2.01	0.496738
inflation	1.42	0.706069
fdi	1.43	0.699204
trade	1.30	0.768274
unemployment	1.27	0.784399

interest rate	1.23	0.812655
wages	1.01	0.991303
Mean VIF	1.49	.

Source: Author's calculation

The Variance Inflation Factor (VIF) results indicate that multicollinearity is not a concern in this model. The mean VIF is 1.49**,** which is well below the commonly accepted threshold of 5, confirming that the independent variables are not excessively correlated. The highest VIF value is 2.23 for population**,** which remains far below critical thresholds (typically 5 or 10), suggesting that while population shares some variance with other variables, it does not pose a significant collinearity issue. Conversely, the lowest VIF value is 1.01 for wages**,** indicating almost no multicollinearity for this variable. Additionally, the 1/VIF (Tolerance) values reinforce these findings, with the lowest value being 0.447642 for population**,** meaning 44.7% of its variance is not explained by other predictors**.** Since all tolerance values exceed 0.1**,** no variables exhibit extreme multicollinearity, ensuring the stability and reliability of the regression model.

1.7 Static regression results

In this section, the general framework of panel Autoregressive distributed lag (panel ARDL) based on the three alternative estimators is reviewed. First of all, it is important to mention that the standard panel models are usually associated with some drawbacks related to the imposed restrictions. To name a few, the pooled ordinary least square (OLS) is a highly restricted model because this method imposed the same intercept and slope for all cross-sections or the fixed effects model establishes common slopes and variance. Additionally, Campos and Kinoshita (2008) point out the bias that can be found in the fixed

effects model when some regressors are endogenous and correlated with the error terms. Moreover, although the random effects model does not offer so many problems in terms of degrees of freedom, it does not guarantee the strict exogeneity (Arellano, 2003). For these reasons, to overcome these shortcomings and due to the fact that panel ARDL methodology is able to determine coefficients of a short- and long-term nature simultaneously (Thampanya et al., 2021), this paper implements the panel ARDL applying three different estimators: Mean Group (MG) estimator, Dynamic Fixed Effects (DFE) estimator and the Pooled Mean Group (PMG) estimator. One of the main advantages is that panel ARDL does not force the variables to have the same order of integration to corroborate a long-run relationship. In other words, the panel ARDL estimation can efficiently perform regardless of the level of integration of the variables (Fang et al., 2015; Kim et al., 2010).

1.7.1 Pooled Mean Group and its results

The first estimator is the PMG. According to Pesaran, Shin and Smith (1999), PMG is a combination of pooling and averaging of coefficients. The PMG constrains the long run elasticity to be equal across all panels which yields efficient and consistent estimates only when homogeneity restriction is true (Casni, Badurina and Sertic, 2014). PMG also has the advantage of allowing for the heterogeneous short run dynamics for each cross section (Kang, 2006). The short run adjustment is allowed to be country specific. This is due to different impact of vulnerabilities to external shocks, monetary policy and others. So as stated before. the main characteristic of the first estimator (PMG) is that it allows short-run coefficients, including the intercepts, the speed of adjustment to the long run equilibrium values, and error variances to be heterogeneous country by country while the long-run slop coefficients are restricted to be homogeneous across countries. Rafindadi & Yosuf (2013).

Table 1.6 results of Pooled Mean Group

Pooled Mean Group Regression

Obs per group: min = 32
Number of groups = 20
Number of obs = 640

D.gdp	Coefficient	Std. err.	z	P>z	[95% conf.	interval]
ec						
trade	-0.036012	0.023226	-1.55	0.121	-0.081536	0.009511
wages	-0.000279	0.003331	-0.08	0.933	-0.006808	0.006250
interest rate	-0.001197	0.000747	-1.60	0.109	-0.002661	0.000267
fdi	0.111207	0.031574	3.52	0.000	0.049321	0.173092
inflation	-0.014103	0.023667	-0.60	0.551	-0.060490	0.032283
population	-0.005094	0.002024	-2.52	0.012	-0.009061	-0.001127
education	-0.012889	0.028797	-0.45	0.654	-0.069330	0.043552
unemployment	-0.070251	0.020655	-3.40	0.001	-0.110736	-0.029767
SR						
ec	-0.881850	0.05240	-16.83	0.000	-0.984556	-0.779144
trade						
D1.	0.342524	0.081427	4.21	0.000	0.182929	0.502119
wages						
D1.	0.021591	0.007577	2.85	0.004	0.00674	0.036443
interest rate						
D1.	-0.001963	0.001918	-1.02	0.306	-0.005723	0.001795
fdi						
D1.	0.049220	0.0363915	1.35	0.176	-0.022105	0.120546
inflation						
D1.	-0.190726	0.097800	-1.95	0.051	-0.382412	0.000959
population						
D1.	0.038257	0.056706	0.67	0.500	-0.072884	0.149399
education						
D1.	-0.1125895	0.1117894	-1.01	0.314	-0.331692	0.106513
unemployment						
D1.	-0.436071	0.064846	-6.72	0.000	-0.563168	-.0308974
_cons	3.247321	0.19533	16.62	0.009	2.86447	3.630173

Source: Author's calculation

The Pooled Mean Group (PMG) regression results provide insights into both the long-run and short-run relationships between GDP growth and the independent variables in the model. The estimation is based on panel data from 20 countries over 32 years (total of 640 observations), using PMG estimation, which allows short-run coefficients to vary across groups while constraining long-run coefficients to be homogeneous. The long-run coefficients represent how each independent variable affects GDP growth over time. Trade (-0.0360, p = 0.121) The coefficient is negative, meaning that trade might slightly reduce GDP growth in the long run. However, this effect is statistically insignificant ($p > 0.05$), meaning there is no strong evidence of a long-run relationship between trade and GDP growth. Wages (-0.0003, p = 0.933) has a very small negative coefficient that is not significant, suggesting that wages do not have a long-run impact on GDP growth. Interest Rate (-0.00119, p = 0.109) A negative but marginally insignificant coefficient, indicating that higher interest rates may reduce GDP growth, but the effect is not statistically strong. Foreign Direct Investment (FDI) (0.1112, p = 0.000) A positive and highly significant coefficient, showing that higher FDI inflows significantly contribute to long-term economic growth. Inflation (0.0141, p = 0.551): A small positive coefficient that is not statistically significant, implying that inflation does not have a notable long-run impact on GDP growth. Population (-0.0050, p = 0.012): A negative and significant coefficient, indicating that an increasing working-age population might reduce long-term GDP growth. This could be due to underemployment or labor market inefficiencies. Education (-0.0128, p = 0.654): A negative but insignificant effect, suggesting that education levels do not significantly influence GDP growth in the long run. Unemployment (-0.0703, p = 0.001): A negative and highly significant coefficient, meaning that higher unemployment rates

significantly reduce GDP growth in the long run. The short-run coefficients show the immediate impact of changes in the independent variables on GDP growth. Error Correction Term (ec) (-0.8818, p = 0.000): A negative and highly significant coefficient, confirming that the system returns to equilibrium after a shock. The speed of adjustment is 88.15% per period, indicating a strong correction process. Trade (D1. 0.3425, p = 0.000): A positive and highly significant coefficient, suggesting that short-term increases in trade contribute significantly to GDP growth. This confirms that trade has an immediate beneficial effect on economic performance. Wages (D1. 0.0215, p = 0.004): A positive and significant coefficient, meaning that short-term increases in wages contribute positively to GDP growth. This could reflect the immediate boost in consumer spending. Interest Rate (D1. -0.0019, p = 0.306): A negative but insignificant coefficient, indicating that short-term changes in interest rates do not significantly impact GDP growth. FDI (D1. 0.0492, p = 0.176): A positive but insignificant coefficient, suggesting that short-term fluctuations in FDI do not significantly influence GDP growth. Inflation (D1. -0.1907, p = 0.051): A negative coefficient that is nearly significant, suggesting that short-term inflation may slightly reduce GDP growth. Population (D1. 0.0383, p = 0.500): A positive but insignificant coefficient, meaning that short-term population changes do not have a strong effect on GDP growth. Education (D1. -0.1126, p = 0.314): A negative but insignificant coefficient, indicating that short-term education level changes do not significantly impact GDP growth. Unemployment (D1. -0.4361, p = 0.000): A negative and highly significant coefficient, confirming that rising unemployment reduces GDP growth in the short term. Constant Term (cons, 3.2473, p = 0.000) means that the positive and significant constant

term suggests that, even when all independent variables are zero, GDP growth remains positive.

1.7.2 Mean Group and its results

The second estimator is the MG estimator which was also developed by Pesaran and Smith (1995) and it is characterized by estimating a regression for each country and then it computes the coefficients using unweighted means. All coefficients are allowed to be country-specific (i.e. heterogeneous) and time-varying in the short- and in the long-run. In other words, the (MG) estimator is suggested in order to resolve the bias due to heterogeneous slopes in dynamic panels, the MG estimator, provides the long-run parameters for the panel through making an average of the long-run parameters from ARDL models for individual countries. It does not impose any restriction. It allows for all coefficients to vary and be heterogeneous in the long-run and short-run. However, the necessary condition for the consistently and validity of this approach is to have a sufficiently large time-series dimension of the data. Rafindadi & Yosuf (2013).

Table 1.7 results of Mean Group

Mean Group Estimation

D.gdp	Coefficient	Std. err.	z	P>z	[95% conf.	interval]
ec						
trade	0.16093	0.13871	1.16	0.246	-0.11094	0.43279
wages	0.00883	0.01135	0.78	0.437	-0.01342	0.03108
interest_rate	0.00245	0.00308	0.80	0.426	-0.00358	0.00848
fdi	0.06532	0.10444	0.63	0.532	-0.13937	0.27001
inflation	0.07443	0.21532	0.35	0.73	-0.34760	0.49646
population	-0.01094	0.01438	-0.76	0.447	-0.03912	0.01723
education	0.24182	0.22155	1.09	0.275	-0.19241	0.67604
unemployment	-0.13345	0.05604	-2.38	.017	-0.24329	-0.02361
SR						
ec	-1.30514	0.05224	-24.98	0.000	-1.40753	-1.20274

trade						
D1.	0.26040	0.09648	2.70	0.007	0.07131	0.44950
wages						
D1.	0.01052	0.01189	0.89	0.376	-0.01277	0.03382
Interest rate						
D1.	-0.00188	0.00207	-0.91	0.364	-0.00594	0.00218
fdi						
D1.	-0.01965	0.07815	-0.25	0.080	-0.17282	0.13353
inflation						
D1.	-0.11238	0.09279	-1.21	0.226	-0.29425	0.06948
population						
D1.	0.13404	0.12562	1.07	0.286	-0.11216	0.38024
education						
D1.	-0.31959	0.27852	-1.15	0.251	-0.86549	0.22630
unemployment						
D1.	-0.37473	0.11048	-3.39	0.001	-0.59126	-0.15820
_cons	3.67115	1.41106	2.60	0.009	0.90552	6.43679

Source: Author's calculation

The Mean Group (MG) regression estimates both the long-run (EC) and short-run (SR) relationships between GDP growth and the independent variables across 20 countries. The MG estimator allows both short-run and long-run coefficients to vary across countries, making it useful when cross-country heterogeneity is present. The Mean Group (MG) estimation results reveal notable differences in the drivers of GDP growth across countries. In the long run, trade shows a positive but insignificant impact on GDP growth (0.1609, p = 0.246), suggesting that while trade liberalization may be beneficial, its effects vary across countries. Wages have an insignificant positive impact (0.0083, p = 0.437), implying that wage disparities do not strongly influence long-term growth. Interest rates also have an insignificant positive effect (0.0024, p = 0.426), indicating that variations in interest rates

may not be a decisive factor for long-run economic performance. FDI is positively associated with GDP growth (0.0653, p = 0.532), although its insignificance suggests that FDI's effects may depend on country-specific factors such as governance and infrastructure. Inflation shows a small but statistically insignificant positive effect (0.0741, p = 0.730), meaning that moderate inflation may not harm long-run growth. Population growth has a negative but insignificant impact (-0.0190, p = 0.447), which contrasts with traditional theories suggesting that a growing labor force should contribute to GDP growth. Education has a slightly negative but insignificant effect (-0.2418, p = 0.275), indicating that while education is crucial for development, its effects may take longer to materialize. Unemployment has a significant negative effect on GDP growth (-0.1335, p = 0.017), reaffirming the critical role of labor market policies in sustaining long-term growth. In the short run, trade significantly boosts GDP growth (0.2604, p = 0.007), demonstrating the immediate benefits of increased trade activity. Unemployment negatively impacts GDP growth in the short run (-0.3747, p = 0.001), underscoring the need for short-term job creation strategies. The error correction term (-1.3051, p = 0.000) suggests a rapid adjustment back to equilibrium, confirming that GDP growth deviations correct themselves at a rate of 130.51% per period. Given these results, policymakers should focus on reducing unemployment, enhancing FDI absorption capacity, developing trade-friendly policies, and investing in human capital development to achieve sustainable economic expansion.

1.7.3 Hausman Specification test between PMG and the MG and its results

The Hausman test, in its traditional application, compares an estimator that is efficient under certain assumptions to an estimator that is consistent under more general assumptions. The test helps you decide if the more efficient estimator is still consistent. In

this case the Hausman test plays a crucial role when comparing the Pooled Mean Group (PMG) estimator and the Mean Group (MG) estimator in panel data analysis. It helps decide which estimator is more appropriate for your data based on the assumptions about the homogeneity of the long-run coefficients. It is used to determine whether the PMG estimator (which assumes homogeneous long-run coefficients) is consistent and efficient compared to the MG estimator (which allows for heterogeneous long-run coefficients). The null hypothesis (H_0) of the Hausman test states that the difference in coefficients between the MG and PMG estimators is not systematic, meaning that the PMG estimator is more efficient under H_0, while the MG estimator is preferred if H_0 is rejected.

Table 1.8 results of Hausman Specification Test

Hausman (1978) specification test

	Coef.
Chi-square test value	3.24
P-value	0.9182

Source: Author's calculation

Chi-squared statistic (= 3.24) This is the test statistic for the Hausman test, which compares the differences in coefficients between MG and PMG. P-value (0.9182) – A high p-value (greater than 0.05) means that we fail to reject the null hypothesis. In other words, the differences in coefficients between the MG and PMG estimators are not systematic, suggesting that the PMG model is the more efficient and appropriate choice. This suggests that the long-run relationships among the variables are homogeneous across

the panel, and the PMG model provides more efficient and reliable estimates. As a result, the analysis should rely on the PMG results for interpretation and policy recommendations.

1.7.4 Dynamic Fixed Effects Regression and its results

The third estimator DFE estimator is remarkably similar to the PMG estimator in that it limits the slope coefficient and error variances to be equal across all countries, Abimbola et al. (2023) however; it confines the coefficient of the co-integrating vector to be equal across all panels in the long run. The FE model further restricts the speed of adjustment coefficient and the short-run coefficient to be equal. Dynamic fixed effect model allows panel-specific intercepts. DFE also calculate the standard error while making allowance of intragroup correlation. As discussed in Baltagi, Grin, and Xiong (2000), FE models are subject to a simultaneous equation bias from the endogeneity between the error term and the lagged dependent variable. Rafindadi & Yosuf (2013).

Table 1.9 results of Dynamic Fixed Effects Regression (DFE)

Dynamic Fixed Effects Regression

D.gdp	Coefficient	Std. err.	z	P>z	[95% conf.	interval]
ec						
trade	0.042854	0.033480	1.28	0.201	-0.022766	0.108475
wages	0.012038	0.006351	1.90	0.058	-0.000409	0.024486
interest_rate	-0.000432	0.000779	-0.56	0.579	-0.001959	0.001094
fdi	0.016187	0.047791	0.34	0.735	-0.077481	0.109856
inflation	-0.024095	0.031317	-0.77	0.442	-0.085476	0.037286
population	0.000039	0.003093	0.01	0.990	-0.006024	0.006103
education	-0.093488	0.040868	-2.29	0.022	-0.173589	-0.173589
unemployment	-0.021836	0.028188	-0.77	0.439	-0.077083	0.033411
SR						
ec	-0.81528	0.03650	-22.33	0.000	-0.88683	-0.74373
trade						
D1.	0.17293	0.04767	3.63	0.000	0.07950	0.26637
wages						
D1.	0.00254	0.00342	0.74	0.458	-0.00416	0.00925

Interest rate						
D1.	-0.00209	0.00096	-2.18	0.029	-0.00398	-0.00021
fdi						
D1.	0.07495	0.04262	1.76	0.079	-.008591	0.15850
inflation						
D1.	-0.19341	0.03794	-5.10	0.000	-0.26778	-0.11903
population						
D1.	0.01891	0.02644	0.72	0.474	-0.03290	0.07074
education						
D1.	-0.08586	0.08005	-1.07	0.283	-0.24276	0.07104
unemployment						
D1.	-0.36574	0.03496	-10.46	0.000	-0.43426	-0.29721
_cons	2.85140	0.27994	10.19	0.000	2.30273	3.40008

Source: Author's calculation

The Dynamic Fixed Effects (DFE) regression analysis provides a comprehensive evaluation of the short-run and long-run determinants of GDP growth in Latin America and the Caribbean. The error correction term (-0.8153, p = 0.000) is highly significant and negative, confirming the presence of a long-run equilibrium relationship and indicating that approximately 81.52% of deviations from GDP growth are corrected annually. In the long-run, key economic factors display mixed impacts on GDP growth. Trade exhibits a positive but insignificant effect (0.04285, p = 0.201), suggesting that trade liberalization alone is insufficient to drive sustained economic growth without complementary policies. Wages (0.01203, p = 0.578) and interest rates (-0.0004, p = 0.579) show negligible effects, reinforcing the idea that wage variations and interest rate changes alone do not significantly influence long-term economic performance. While Foreign Direct Investment (FDI) is positively linked to GDP growth (0.01618, p = 0.735), its insignificance suggests that FDI effectiveness depends on domestic absorptive capacity. Inflation negatively affects GDP

growth (-0.0240, p = 0.442), aligning with the expectation that moderate inflation can harm economic performance. Population growth's negligible impact (-0.00003, p = 0.990) suggests that rapid expansion alone does not directly contribute to GDP growth. Notably, education presents a weak but significant negative effect (-0.0934, p = 0.022), possibly indicating a brain drain phenomenon, where higher education levels lead to talent migration, reducing potential economic contributions. Unemployment (-0.0218, p = 0.439) also exerts a negative but insignificant effect, implying that its impact on GDP growth is subject to structural labor market factors. In the short-run, some variables demonstrate stronger relationships with GDP growth. Trade significantly boosts short-run economic performance (0.1729, p = 0.000), reinforcing the importance of trade openness for immediate gains. Interest rates have a negative short-run impact (-0.00209, p = 0.029), suggesting that higher borrowing costs can constrain investment and consumption. Inflation exerts a strong negative effect (-0.1934, p = 0.000) on short-run GDP growth, emphasizing the destabilizing effects of price volatility on economic activity. FDI has a positive but weak short-run impact (0.0749, p = 0.079), suggesting that its full benefits may take time to materialize. Unemployment significantly constrains economic activity (-0.3657, p = 0.000), highlighting the need for labor market policies that foster job creation. Other factors, such as wages (0.0025, p = 0.458), population growth (0.0189, p = 0.474), and education (-0.0859, p = 0.283), show minimal short-run impacts, suggesting that their economic influence requires longer periods to manifest. Overall, the DFE results indicate that trade liberalization, employment growth, and inflation control are critical for economic stability and expansion. Policymakers should prioritize job creation programs, as unemployment significantly hampers short-run GDP growth. Additionally, controlling

inflation is essential to prevent its destabilizing effects on investment and consumption. Interest rate policies must be carefully managed to avoid excessive constraints on economic activity. While FDI and education investments are vital for long-term growth, their effectiveness depends on how well economies retain skilled labor and absorb foreign capital. A balanced policy approach, integrating trade openness, labor market reforms, inflation control, and FDI optimization, will be crucial for sustained economic growth in the region.

1.7.5 Hausman specifications test between Mean Group and Dynamic fixed effects regression and its results.

The Hausman test is used to determine whether the Mean Group (MG) estimator or the Dynamic Fixed Effects (DFE) estimator is more appropriate for panel data analysis. The null hypothesis (H_0) of the test states that the difference in coefficients between the MG and DFE estimators is not systematic, meaning that the DFE estimator is more efficient under H_0, while the MG estimator is preferred if H_0 is rejected.

Table 1.10 results of Hausman Specification Test

Hausman (1978) specification test

	Coef.
Chi-square test value	0.01
P-value	1.0000

Source: Author's calculation

Since the p-value (1.0000) is extremely high, we fail to reject the null hypothesis, meaning that the DFE estimator is preferred over the MG estimator. This suggests that assuming homogeneity in long-run relationships across the panel is appropriate, and using the DFE model will provide more efficient and reliable estimates. Consequently, the analysis should rely on the DFE results for interpretation and policy recommendations rather than the MG/PMG estimates.

1.7.6 Hausman specifications test between Pooled Mean Group and Dynami fixed effects regression and its results.

After running the previous hausman tests between the MG and the PMG estimator, it seems that the PMG estimator is preferred over the MG estimator. And after running the hausman test again between the MG and the DFE estimator, it seems that the DFE estimator is preferred over the MG estimator. We now need to directly compare the PMG and the DFE estimator next. This Hausman test is used to determine whether the Pooled Mean Group (PMG) estimator or the Dynamic Fixed Effects (DFE) estimator is more appropriate for our panel data model. If the null hypothesis (H_0) is not rejected, the DFE estimator is preferred because it assumes homogeneity in both the long-run and short-run parameters across all countries. Alternative Hypothesis (H_1): The difference in coefficients is systematic, meaning that PMG is preferred over DFE.

Table 1.11 results of Hausman Specification Test

Hausman (1978) specification test

	Coef.
Chi-square test value	0.16
P-value	1.0000

Source: Author's calculation

The Chi-squared statistic = 0.16 which is very low and the p-value = 1.0000 which is extremely high, meaning the test strongly fails to reject the null hypothesis. The differences between PMG and DFE are not systematic, meaning that DFE is the preferred estimator. Given that the DFE estimator is preferred, it implies that across the countries in this dataset, the economic relationships between variables exhibit a high degree of uniformity in both the long run and short run. This suggests that regional or international policy frameworks could be effective in addressing issues related to trade, employment, and investment since the effects of these factors are not significantly different across countries.

1.7.7 Best results estimator (DFE estimator)

Table 1.12 results of Dynamic Fixed Effects Regression (DFE)

Dynamic Fixed Effects Regression

D.gdp	Coefficient	Std. err.	z	P>z	[95% conf.	interval]
ec						
trade	0.042854	0.033480	1.28	0.201	-0.022766	0.108475
wages	0.012038	0.006351	1.90	0.058	-0.000409	0.024486
interest_rate	-0.000432	0.000779	-0.56	0.579	-0.001959	0.001094
fdi	0.016187	0.047791	0.34	0.735	-0.077481	0.109856
inflation	-0.024095	0.031317	-0.77	0.442	-0.085476	0.037286
population	0.000039	0.003093	0.01	0.990	-0.006024	0.006103
education	-0.093488	0.040868	-2.29	0.022	-0.173589	-0.173589

unemployment	-0.021836	0.028188	-0.77	0.439	-0.077083	0.033411
SR						
ec	-0.81528	0.03650	-22.33	0.000	-0.88683	-0.74373
trade						
D1.	0.17293	0.04767	3.63	0.000	0.07950	0.26637
wages						
D1.	0.00254	0.00342	0.74	0.458	-0.00416	0.00925
Interest rate						
D1.	-0.00209	0.00096	-2.18	0.029	-0.00398	-0.00021
fdi						
D1.	0.07495	0.04262	1.76	0.079	-.008591	0.15850
inflation						
D1.	-0.19341	0.03794	-5.10	0.000	-0.26778	-0.11903
population						
D1.	0.01891	0.02644	0.72	0.474	-0.03290	0.07074
education						
D1.	-0.08586	0.08005	-1.07	0.283	-0.24276	0.07104
unemployment						
D1.	-0.36574	0.03496	-10.46	0.000	-0.43426	-0.29721
_cons	2.85140	0.27994	10.19	0.000	2.30273	3.40008

Source: Author's calculation

1.7.8 Granger causality test and its results

The Dumitrescu & Hurlin (2012) test was applied to ascertain the causality relationship between the variables. Dumitrescu & Hurlin Granger non-causality test Table (4.12) shows Dumitrescu-Hurlin panel causality test.

Table 1.13 Dumitrescu-Hurlin panel causality tests

Variable combinations	WBar-Statistic	ZBar-statistic	P-value	Conclusion
GDP-Trade	0.9406	-0.3805	0.7036	GDP Granger-causes trade for at least one panel (country)
Trade-GDP	2.0420	2.7592	0.0058	Trade does not Granger-cause GDP
Unempl -Trade	3.6082	7.2240	0.0000	Unemployment Granger-causes trade for at least one panel (country).
Trade-Unempl	3.8485	7.9091	0.0000	Trade Granger-causes unemployment for at least one panel (country)
Wages-Trade	1.7617	1.9603	0.0500	Wages does not Granger-cause trade
Trade -Wages	1.3637	0.8258	0.4089	Trade Granger-causes wages for at least one panel (country).
Intr rate -Trade	1.9786	2.5785	0.0099	Interest_rate Granger-causes trade for at least one panel (country).

Trade - Intr rate	1.9389	2.4654	0.0137	Trade Granger-causes interest_rate for at least one panel (country).
FDI -Trade	1.5650	1.3994	0.1617	FDI does not significantly Granger-cause trade at the 5% level, but there is weak evidence of a relationship.
Trade - FDI	1.5744	1.4262	0.1538	Trade does not significantly Granger-cause FDI at the 5% level, but there is weak evidence of a relationship.
Infl -Trade	1.7279	1.8639	0.0623	Inflation does not Granger-cause trade.
Trade - Infl	1.3312	0.7331	0.4635	Trade Granger-causes inflation for at least one panel (country).
Pop -Trade	9.0231	22.6602	0.0000	Population Granger-causes trade for at least one panel (country).
Trade - Pop	3.1606	5.9480	0.0000	Trade Granger-causes population for at least one panel (country).

Edu -Trade	2.0351	2.6736	0.0075	Education Granger-causes trade for at least one panel (country).
Trade - Edu	3.4621	6.6435	0.0000	Trade Granger-causes education for at least one panel (country).

Source: Author's calculation

Trade and Unemployment: A bidirectional causality exists. Trade affects unemployment, and unemployment affects trade in at least some countries. Trade and GDP: Unidirectional causality exists. GDP affects trade, but trade does not significantly affect GDP. There is unidirectional causality from trade to wages. This means that changes in trade can influence the wages, but changes in the wages do not significantly influence trade. There is bidirectional causality between trade and interest rate. This means that changes in trade can influence interest rates, and changes in interest rates can also influence trade, at least in some countries. There is no strong evidence of causality in either direction between trade and FDI at the 5% significance level. However, the p-values are close to 0.05, suggesting a potential weak relationship that might be worth exploring further with more data or different methodologies. There is unidirectional causality from trade to inflation. This means that changes in trade can influence inflation, but changes in inflation do not significantly influence trade. There is bidirectional causality between trade and population. This means that changes in trade can influence population dynamics, and changes in population can also influence trade, at least in some countries. There is bidirectional

causality between trade and education. This means that changes in trade can influence education, and changes in education can also influence trade, at least in some countries.

1.8 Conclusion, Recommendations and Limitations

1.8.1 Conclusion

The reason for this study was to analyze the impact of trade on economic growth in Latin America and the Caribbean covering the period from 1990 to 2023 for a total of 20 nations, panel data was applied. The dependent variable is GDP and the independent variable is Trade. The control variables are Interest rates, Wages, Education, FDI, Unemployment, Inflation, Population. The Dynamic fixed effect (DFE) estimator of the ARDL model was applied in this study in order to analyze the impact of trade and GDP.

The Dynamic Fixed Effects (DFE) regression analysis provides a comprehensive evaluation of the short-run and long-run determinants of GDP growth in Latin America and the Caribbean. The error correction term (-0.8153, p = 0.000) is highly significant and negative, confirming the presence of a long-run equilibrium relationship and indicating that approximately 81.52% of deviations from GDP growth are corrected annually. In the long-run, key economic factors display mixed impacts on GDP growth. Trade exhibits a positive but insignificant effect (0.04285, p = 0.201), suggesting that trade liberalization alone is insufficient to drive sustained economic growth without complementary policies. Wages (0.01203, p = 0.058) and interest rates (-0.0004, p = 0.579) show negligible effects, reinforcing the idea that wage variations and interest rate changes alone do not significantly influence long-term economic performance. While Foreign Direct Investment (FDI) is positively linked to GDP growth (0.01618, p = 0.735), its insignificance suggests that FDI

effectiveness depends on domestic absorptive capacity. Inflation negatively affects GDP growth (-0.0240, p = 0.442), aligning with the expectation that moderate inflation can harm economic performance. Population growth's negligible impact (-0.00003, p = 0.990) suggests that rapid expansion alone does not directly contribute to GDP growth. Notably, education presents a weak but significant negative effect (-0.0934, p = 0.022), possibly indicating a brain drain phenomenon, where higher education levels lead to talent migration, reducing potential economic contributions. Unemployment (-0.0218, p = 0.439) also exerts a negative but insignificant effect, implying that its impact on GDP growth is subject to structural labor market factors. In the short-run, some variables demonstrate stronger relationships with GDP growth. Trade significantly boosts short-run economic performance (0.1729, p = 0.000), reinforcing the importance of trade openness for immediate gains. Interest rates have a negative short-run impact (-0.00209, p = 0.029), suggesting that higher borrowing costs can constrain investment and consumption. Inflation exerts a strong negative effect (-0.1934, p = 0.000) on short-run GDP growth, emphasizing the destabilizing effects of price volatility on economic activity. FDI has a positive but weak short-run impact (0.0749, p = 0.079), suggesting that its full benefits may take time to materialize. Unemployment significantly constrains economic activity (-0.3657, p = 0.000), highlighting the need for labor market policies that foster job creation. Other factors, such as wages (0.0025, p = 0.458), population growth (0.0189, p = 0.474), and education (-0.0859, p = 0.283), show minimal short-run impacts, suggesting that their economic influence requires longer periods to manifest. Overall, the DFE results indicate that trade liberalization, employment growth, and inflation control are critical for economic stability and expansion. Policymakers should prioritize job creation programs, as

unemployment significantly hampers short-run GDP growth. Additionally, controlling inflation is essential to prevent its destabilizing effects on investment and consumption. Interest rate policies must be carefully managed to avoid excessive constraints on economic activity. While FDI and education investments are vital for long-term growth, their effectiveness depends on how well economies retain skilled labor and absorb foreign capital. A balanced policy approach, integrating trade openness, labor market reforms, inflation control, and FDI optimization, will be crucial for sustained economic growth in the region.

Recommendations

The DFE results suggest that trade liberalization, employment growth, and inflation control are critical for economic stability and growth in Latin America and the Caribbean. In the long run, FDI and education investments should be optimized to ensure their positive contributions to economic development. Policymakers should focus on reducing unemployment, as its significant negative impact in the short run highlights the need for job creation initiatives and workforce training programs. Additionally, controlling inflation is essential, as high inflation negatively impacts short-run GDP growth. Interest rate policies should be carefully managed to prevent excessive restrictions on investment and consumption. Overall, a balanced approach combining trade openness, labor market reforms, inflation control, and FDI absorption strategies will help foster sustainable economic growth. The DFE findings also emphasize the importance of trade openness, employment growth, and inflation control for economic stability and growth in Latin America and the Caribbean. Given the negative and significant short-run effects of unemployment on GDP, policymakers should prioritize job creation initiatives, vocational

training, and labor market reforms to enhance workforce participation and productivity. Inflation control should be a key focus, as high inflation negatively impacts short-term economic stability. Interest rate policies should be carefully managed to balance inflation control with investment incentives. In the long run, FDI and education investments need to be optimized to ensure their effectiveness in contributing to GDP growth. Overall, a comprehensive strategy combining trade policies, labor market reforms, inflation management, and FDI absorption mechanisms will be crucial for fostering sustainable economic growth in the region. Policymakers should consider the interplay between trade and unemployment when designing economic policies. For example, trade policies (e.g., tariffs, trade agreements) may impact unemployment rates, and unemployment levels may influence trade dynamics. Since GDP influences trade, efforts to boost GDP (e.g., through investment, innovation, or infrastructure development) could positively impact trade activities. However, trade policies alone may not significantly drive GDP growth in the short term. Policymakers should also consider the impact of trade policies on wage differentials. For example, trade liberalization or restrictions could influence wage disparities across different sectors or regions. The bidirectional relationship between trade and interest rates suggests that trade policies and monetary policies are interconnected. Central banks may need to consider trade dynamics when setting interest rates, and trade policies may need to account for interest rate changes. While there is no strong evidence of causality between trade and FDI, policymakers should still consider the potential interplay between these variables, especially in the context of attracting foreign investment and promoting trade. The unidirectional causality from trade to inflation suggests that trade policies (e.g., tariffs, trade agreements) could have an impact on inflation. Policymakers

should consider the inflationary effects of trade policies when designing economic strategies. Policymakers should consider the impact of trade policies on population dynamics, such as migration, urbanization, or population growth. For example, trade liberalization might attract labor migration to certain regions, influencing population distribution. Population changes (e.g., growth, density, or demographic shifts) can influence trade patterns, such as demand for goods and services or labor availability. Policymakers should consider population trends when designing trade strategies. Policymakers should also consider the impact of trade policies on education. For example, trade liberalization might increase demand for skilled labor, leading to investments in education and training programs. Education levels can also influence trade patterns by affecting the skill level of the workforce, innovation, and productivity. Policymakers should consider the role of education in enhancing trade competitiveness.