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IMPACT OF TRADE OPENNESS ON INFLATION: EXPLORING THE ROLE OF DIGITALIZATION

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ABSTRACT

Many empirical studies have been conducted on the relationship between trade openness and inflation since Romer's hypothesis (1993). The current study examines the relationship between inflation and trade openness, as well as the threshold level of digitalization. The study uses balanced panel data from 1996 to 2023. It employs the system (GMM) method to determine the impact of trade openness on inflation and estimate the threshold level of digitalization for the heterogeneous income groups of countries. Previous research has shown both positive and negative relationships between inflation and trade openness in different countries, both individually and regionally, while other studies have focused solely on a panel of countries. The present study addresses the following gaps: firstly, the overall global impact on all income levels remains unexamined. Secondly, it examines the moderating role of digitalization, including identifying the threshold level of digitalization. The study's findings revealed that trade openness has a significant positive impact on inflation before including the interaction term. When trade openness interacts with digitalization, we observe both positive and negative results due to the threshold, despite the interaction term being significant and positive. Overall, the effect of trade openness on inflation remains negative in the presence of digitalization in our sample, indicating that the level of digitalization in our dataset is below the threshold (47.8%). Therefore, trade openness continues to have a deflationary effect. Policymakers should promote productivity, price transparency, and supply chain efficiency to help lower inflation. They should also consider the level of digitalization when designing targeted policies to manage trade openness on inflation.

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Introduction

According to the Romer hypothesis (1993), trade openness is associated with reduced inflation. The author gave empirical evidence that trade openness and inflation are negatively correlated at the international level. Two reasons are possible when there is an inverse relationship between trade openness (TO) and inflation (INF); first, open trade makes an economy more competitive, thereby reducing the levels of inflation(INF). Second, trade openness may lead to diversification, which will also lower the overall inflation at the cost of decreasing the price shock.

TO and INF have a complicated and highly debated relationship. Some studies have shown that TO can result in lower INF rates (Romer hypothesis, 1993), because increased competition and access to cheaper imports can help decrease domestic prices (Rodrik, 1998). Therefore, TO can lead to reduced INF, especially if a country sees an increase in imports (Obstfeld and Rogoff, 1996). The TO and INF relationship can be affected by a country's economic strength, trading practices, and institutional robustness, especially among nations with different income levels. This relationship helps determine whether increased TO is linked to lower or higher INF rates in emerging economies (Ashra, 2002).

One of the macroeconomic consequences of economies' increased integration into global markets is a change in INF dynamics, which empirically supports the idea that TO and INF are inversely related. It is especially important to understand how TO impacts INF because this information guides policy decisions on tariffs, international trade agreements, and INF control measures (Lane, 1997). Furthermore, the 1980s crisis period saw a TO and INF had a negative correlation, with the latter in highly indebted nations. Consequently, TO tends to control INF since governments in these heavily indebted nations have limited capacity to finance deficits through inflationary means. Less indebted countries show less of this effect, indicating that the economic context affects how openness and inflation interact (Terra, 1998).

Maintaining price stability or a lower rate of inflation is one of the primary objectives of economic policy in the economy of the South Caucasus[1]. The significance of TO in macroeconomic policy is receiving more and more attention as global commerce expands quickly and the economic relationship develops continuously. The economies of the South Caucasus were governed by a centrally planned economy run by the former Soviet Union (Aliyev and Gasimov, 2014). TO and the potential for a significant decrease in INF are negatively linked, according to earlier research. This may be due to strong overseas competition limiting companies' ability to raise prices or high levels of openness reducing policymakers' incentives to adopt expansionary measures. Increased competition in product markets due to increases in TO will make it harder for monopolies to impose inflationary price rises on the supply side. (Bowdler and Nunziata, 2006).

[1] South Caucasus region are Armenia, Azerbaijan, and Georgia.

Digitalization[2] is an important factor, changing financial systems, increasing trade efficiency, and improving information access, all of which are changing how economies work. Therefore, TO and digitalization may combine to affect INF, but neither may be directly responsible for the other. Therefore, the association between TO and INF may be influenced by digitalization, which acts as a moderating element. It is essential to investigate how openness and digitalization interact to shape inflationary or disinflationary effects to get the whole situation. Furthermore, due to technological progress and innovation, trade has become increasingly digitalized, and it has affected the economy, including INF, serving as a threshold that, once digital infrastructure reaches a particular level, increases the advantages of TO in lowering or raising INF. Detailed insights can be acquired by incorporating digitalization as a threshold component using an econometric model (Emara and Zecheru, 2022; Emara and Zecheru, 2024).

Digitalization's indirect impact on INF is ambiguous: While technology may reduce prices by improving pricing transparency and lowering search costs, it may also increase obstacles to entry for competitors, strengthening company market dominance, and raising prices following COVID-19. Through indirect effects like e-commerce, there is some empirical evidence of a slight negative influence of digitalization on INF. However, there is a great deal of uncertainty in these estimations, and many possible impacts of the indirect routes have not been tested empirically. Digitalization has a direct impact on INF through changes in product prices and market trends for both online and offline transactions (Consolo et al., 2021).

By examining important variables that characterize digital progress and economic success, the primary aim is to investigate how digitalization has affected the competitiveness of a few chosen European nations. The importance of digital technology in establishing modern economies is highlighted by the finding that digital transformation is a major force behind innovation, efficiency, and EG in several sectors (Jarzębowski et al.,2024). Digitalization makes it easier for SMEs to access global markets examines the impact that digital technology use has on Spanish small and medium-sized businesses' capacity to reach international markets. Through increased productivity and faster access to a greater market of suppliers and consumers, digitization may assist SMEs in both importing and exporting. It should be mentioned that not all digital technologies affect trade participation in the same way, and automation technologies only affect trade via the productivity channel (Añón and Bonvin, 2024).

The present study discusses previous literature on INF, TO, and digitalization; however, that digitalization as a moderating role and interprets it through a threshold. In recent years, TO has had a major effect on INF. Meanwhile, since COVID-19, digitalization has increased and is affecting the behavior of prices and commerce. It speeds up transactions, lowers expenses, and enhances information availability. The current analysis suggests that digitalization may affect the

[2] Digitalization is the process by which businesses and society transition to the digital world. A common step in the wider adoption of digital technology to transform business models and procedures is the integration of digital tools and systems across various areas of an organization's operations.

connection between inflation and TO. Stated differently, a higher level of digitalization may either increase or reduce the impact of TO on INF. Before this effect is visible, there can also be a threshold or degree of digitalization required.

Significance of Study

In light of the Sustainable Development Goals (SDGs), particularly SDG 8 (Decent Work and Economic Growth), SDG 9 (Industry, Innovation, and Infrastructure), and SDG 17 (Partnerships for the Goals), the current study investigates the relationship between TO, digitalization, and INF from a global perspective (United Nations, 2015). This is among the first studies to evaluate TO and INF on a worldwide scale while taking into consideration the moderating influence of digitalization, a topic that is often overlooked in the empirical literature that currently exists.

Several Sustainable Development Goals (SDGs) may indirectly impact INF. However, INF may hinder the achievement of several SDGs, including those about poverty, hunger, inequality, and sustainable economic growth, even though no single SDG specifically tackles it. Essentially, INF is a crucial issue that can help or hinder the fulfillment of multiple SDGs, even if no SDG specifically addresses it. The study provides a comprehensive understanding of how TO and digitalization affect INF across economies at different stages of development, utilizing global panel data and incorporating income differences at the country level.

In today's global economy, the issue of how TO affects INF, especially when viewed through the perspective of digitalization, is crucial. Policymakers, economists, and companies must comprehend how trade openness affects inflationary dynamics as nations participate in more international commerce. This work is important because it has the potential to enhance our understanding of the relationship between digitalization, INF, and TO.

Furthermore, understanding the threshold impact can help determine how TO and digitalization affect INF for different levels of income. The results of this study will help achieve the SDGs by demonstrating how trade and digital policies can be used to sustain price stability, foster sustainable economic growth, and foster innovation and competitiveness, especially in heterogeneous income groups of countries that are prone to INF.

Literature Review

Studies on the impact of Trade Openness (TO) on Inflation (INF) Country-Level Studies

According to Romer (1993) that being open to trade can help countries control INF. He also suggested that TO can significantly influence INF. However, the Romer hypothesis is not supported by some empirical studies. Yeboah and Baffour (2024) investigated the effect of INF and TO on Ghana's economy from 1990 to 2022. Utilizing the Granger causality test for empirical analysis and the Autoregressive Distributed Lag (ARDL) limits testing for cointegration. There is Ghana's INF is not significantly but positively impacted by TO over the long term. However, Munir et al. (2023) explored how international TO influences INF, using data from Pakistan from 1990 to 2021. The main objective is to use co-integration analysis to investigate the Romer hypothesis, which

postulates a connection between does not hold for INF and TO. The findings show that in Pakistan, TO and INF have a positive long-term association. Romer's theory for Pakistan is rejected by the absence of such a relationship in the short run. Furthermore, Sulehr and Khan (2020) examined the connection between Pakistan's INF and TO using annual data from 1980 to 2014. This study provides empirical evidence, utilizing the ARDL technique, that shows TO and INF are significantly correlated. The empirical findings show that TO and INF do not correlate over the long run, hence refuting Romer's hypothesis for Pakistan. Previous studies have provided contrasting results about INF and TO. Mukhtar et al. (2019) used the connection between INF and TO in Pakistan from 1972 to 2016 and used the nonlinear autoregressive distributed lag (NARDL) methodology. TO and INF have a long-term, positive, and balanced relationship. This implies that there is a steady, long-term correlation between TO and INF. Asymmetrically, the link is also helpful in the short term. This implies that whether TO is growing or contracting can affect how INF reacts to modifications in TO. Against Romer's argument that INF should fall as TO rises, the analysis reveals the case of Pakistan, where INF rises as TO increases.

Recent research, in contrast to previous studies, indicates that the Romer hypothesis is true in Pakistan. For example, Mukhtar (2012) uses multivariate cointegration and, using a vector error correction approach, data from 1960 to 2007 were examined, finding a strong negative long-term relationship between TO and INF. Moreover, Kaukab and Anggara (2024) examined the relationship between TO and INF in Indonesia over the period from 1985 to 2022. The study evaluates the short- and long-term links between Indonesian INF and TO using an Autoregressive Distributed Lag (ARDL) model. It concludes that TO and INF have a long-term positive relationship, which means that as TO increases, INF tends to rise. Hence, it does not accept the Romer hypothesis. Several studies, in contrast to Romer's conclusion, show that the Romer hypothesis is not accepted in India. Using the ARDL model, Chhabra and Alam (2020) examined the connection between INF and TO in India between 1974 and 1975 and 2015 and 2016. To ascertain whether there was a long-term relationship between the variables, the study used the Bounds Testing Approach combined with the co-integration approach described by Pesaran et al. (2001). The study shows a positive relationship between the two variables in India.

This finding suggests that greater TO in India leads to higher INF rates, contrasting with the negative correlation observed in many empirical studies. However, Sahu et al. (2018) examined the relationship between INF and TO in India using quarterly data from 2000Q1 to 2016Q3, utilizing the ARDL. The study uses the Bound Testing Approach methodology to assess whether a long-term relationship exists between the variables. According to the study, TO and INF are positively related in the long run.

Studies on the Impact of Digitalization on Inflation

Emara and Zecheru (2024) used data from 2004 to 2018 to examine the nonlinear link between INF and digitization in 47 emerging economies. The generalized method of moments (GMM) and a threshold regression model are used to show that the effect of digitalization on INF is asymmetrical and varies with the level of digital development. The results demonstrate that the rise in digitization has a precise threshold level and a statistically significant nonlinear deflationary

effect. By increasing efficiency, competition, and price transparency, additional advancements in digital infrastructure significantly reduce INF in economies with high levels of digitization. Emara and Zecheru (2022) investigated how digitization affected domestic INF in 54 developed and emerging economies between 2004 and 2018. The study used the System Generalized Method of Moments (GMM) technique to analyze the deflationary effect of digitization, which is the idea that improvements in digitization lead to a decrease in INF. The biggest deflationary effects are caused by advancements in digital infrastructure and production factors. Moreover, Çoban (2022) investigated the connection between data from 1994 to 2014 and digitalization in the asian-5 countries. The study examined the connection between internet usage and INF in the five Asian nations—Indonesia, Malaysia, the Philippines, Singapore, and Thailand using panel data analysis. The study looked into the relationship between internet usage and INF and estimated the model using the Pooled Least Squares (Pooled OLS) technique. Increased internet use may aid in reducing INF, according to the findings. The study demonstrates how digitalization and INF are negatively correlated.

However, Csonto et al. (2019) investigated how digitalization affected the dynamics of INF in 36 developed and developing nations between 2000 and 2017. The investigation shows that digitization has a statistically significant, short-term negative influence on INF using Phillips curve calculations. Even if the economic impact is minimal, it has grown since 2012, mostly as a result of increased competition and costs. Furthermore, Yi and Choi (2005) examined the correlation between internet usage and INF statistics from a panel dataset spanning 207 nations between 1991 and 2000. The authors' fixed-effects model indicates that more internet use, particularly in industrialized nations, significantly reduces INF. The internet's capacity to increase competition, enhance price transparency, and facilitate information transfer explains the inverse link.

Data and Methodology

Secondary panel data from 118 nations covering 28 years, from 1996 to 2023, are used. The WDI and the IMF are the sources of the data. The main goal is to cover every nation on the globe with data on digitalization, INF, and TO. The data, depending on the World Bank's classification of the nations, the countries have been grouped into four distinct categories based on their income levels in order to account for differences in income levels. Lower middle income ($1,046 to $4,095), higher middle income ($4,096 to $12,695), low income ($1,045 or less), and high income ($12,696 or more) are the four distinct types. The study comprised twenty low-income countries, thirty-five upper-middle-income countries, thirty-four lower-middle-income countries, and twenty-nine high-income countries. The number of low-income countries included in this study is limited because of the unavailability of data. The countries used in this study are listed in Appendix (A1).

The following is a summary of categories and countries included in the study

Table 1: Summary of Countries

Sr. No	Abbreviation	Category	2014 GNI per Capita (July 2015)	Total Number of Countries (According to GNI per Capita)	Total Number of Countries (According to data availability)
1	LIC	Low-Income-Countries	$1,045 or less	27	20
2	LMIC	Lower-Middle-Income-Countries	From $1,046 to $4,125	55	34
3	UMIC	Upper-Middle-Income-Countries	From $4,126 to $12,735	55	35
4	HIC	High-Income-Countries	$12,736 or More	80	29
Total				217	118

Source: Sirajuddin and Fantom (2016). The World Bank's income-based classification of nations.

Data and Description of Variables

Table 2: Descriptions of Variables

Variables	Description/Measurements	Sources	Author's (Included by the following studies, among others).
Inflation (INF) (Dependent variable)	Inflation, as measured by the Consumer Price Index, reflects changes in the cost to the average consumer of acquiring a basket of goods and services that may be fixed or changed at specified intervals, such as yearly. Inflation, consumer prices (annual %)	WDI	Sulehr and Khan; 2020; Sikdar et al., 2013; Parsi, 2024; Çoban, 2022; Munir et al., 2015
Trade openness (TO) (Independent variable)	Trade is the sum of exports and imports of goods and services measured as a share of gross domestic product. Trade (% of GDP)	WDI	Sikdar et al., 2013; Parsi, 2024; Munir et al., 2015
Digitalization (DT) (Independent and moderator variable)	Internet users are individuals who have used the Internet. The Internet can be used via a computer, mobile phone, personal digital assistant, games machine, digital TV, etc. Individuals using the Internet (% of population)	WDI	Prasetyo and Yulinda, 2024; Çoban, 2022; Bakari, 2022

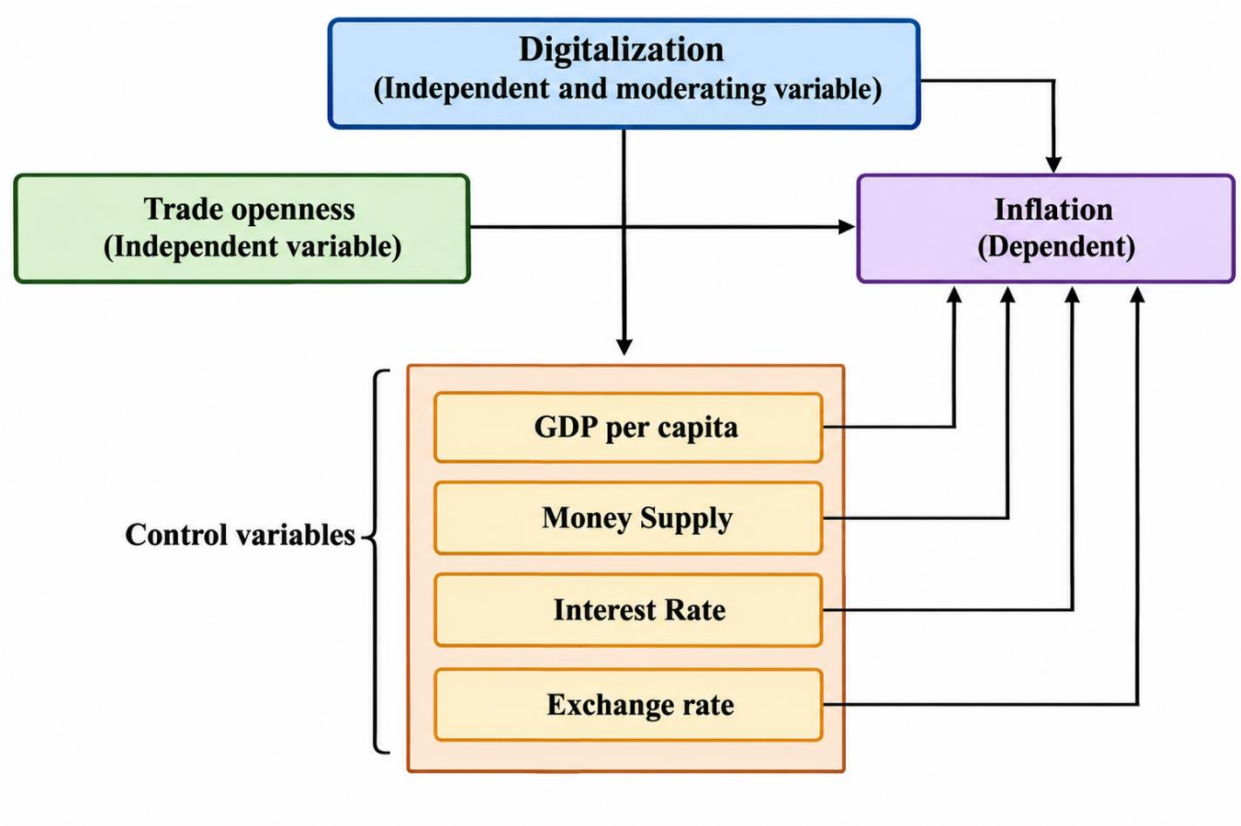
Gross Domestic Product per Capita Growth Rate (GDP)	GDP per capita is gross domestic product divided by midyear population. GDP is the sum of gross value added by all resident producers in the economy, plus any product taxes, minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources. GDP per capita growth (annual %)	WDI	Sulehr and Khan, 2020; Munir et al., 2015; Ashra, 2002
Exchange rate (ER)	The exchange rate shows how many US dollars equal one unit of domestic currency. This is the inverse of the "Domestic currency per US dollar" rate. A measure that indicates how often an event or phenomenon about another quantity. This refers to the arithmetic mean (average) value of a data set calculated over a specific period, such as a month, quarter, or year. It offers a representative value for the entire period, smoothing out short-term fluctuations. US dollar per domestic currency, Period average rate	IMF (IFS)	Sulehr and Khan, 2020; Adefabi, 2023; Munir et al., 2015; Ashra, 2002;Sepehrivand and Azizi, 2016
Money Supply (M2) **Proxy (Broad money)**	Broad money is the sum of currency outside banks; demand deposits other than those of the central government; the time, savings, and foreign currency deposits of resident sectors other than the central government; bank and traveler's checks; and other securities such as certificates of deposit and commercial paper. Broad money (% of GDP)	WDI	Sulehr and Khan, 2020; Sikdar et al., 2013; Munir et al., 2015; Ashra, 2002
Interest Rate (IR)	Interest rate is measured by the Monetary and Financial, Interest Rate, other depository corporation rates, lending rates, and lending rate percent per annum. The terms and conditions attached to lending rates differ by country, however, limiting their comparability. lending rates, percent per annum	IMF (IFS)	Munir et al., 2015; Çoban, 2022

Source: Author's Construction

Conceptual Framework

The conceptual framework for analyzing the TO on INF, with a focus on its moderating role of digitalization across different income groups, is built upon the theoretical background and empirical evidence provided earlier in the present study.

Figure 1: Conceptual Framework



Sources: Author's work based on different studies

Model Specification

The present study follows Munir et al. (2015) and Darkwah et al. (2023) model with some modifications and extends it by including additional control and moderating variables with a dynamic specification. The lag dependent variable is specified in the model to avoid spurious regression (Ghouse et al., 2024).

$$INF_{it} = \alpha_0 + \alpha_1 INF_{it-1} + \alpha_2 TO_{it} + \alpha_3 DT_{it} + \alpha_4 ER_{it} + \alpha_5 GDP_{pcit} + \alpha_6 IR_{it} + \alpha_7 BM_{it} + \varepsilon_{it} \quad \text{..... (1)}$$

Where,

Subscripts i and t are used for the i^{th} country and t^{th} time-period, respectively, and ε_{it} is an error term. The other abbreviations for the variables are described below, and a brief description of each variable is given in Table 3.2 above:

INF_{it} = Inflation

TO_{it} =Trade Openness

DT_{it} =Digitalization

GDP_{pcit} =Gross Domestic Product per capita growth

ER_{it} =Exchange rate

IR_{it} =Interest rate

BM_{it} = Broad Money

Threshold Determination

The model (1) is extended to allow for interaction between TO and digitalization.

$$INF_{it} = \beta_0+\beta_1 INF_{it-1} + \beta_2 TO_{it} + \beta_3 DT_{it}+\beta_4 TO_{it} * DT_{it} + \beta_5 GDP_{pcit} + \beta_6 ER_{it} + \beta_7 IR_{it} + \beta_8 BM_{it} + \varepsilon_{it} \quad \text{.....(2)}$$

The marginal effects of TO on INF are calculated by taking the partial derivative of equation (3.2) as follows:

$$\frac{\partial INF_{it}}{\partial TO_{it}} = \beta_2 + \beta_4 DT_{it} \text{.....(3)}$$

If β_2 and β_4 have the same signs (positive or negative), then it strengthens the effects of TO on INF at different levels of DT, given that $DT \geq 0$. But if β_2 and β_4 have opposite signs, then it weakens the effects of TO on INF at different levels of DT.

However, when the signs are the same, then the effect of TO on INF can be positive or negative. But when the signs are different, then the effect of TO on INF depends on the level of DT[3]. If the level of DT is above or below a certain threshold value of DT, that is, DT*, it changes the direction of effects.

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[3] $\frac{\partial INF_{it}}{\partial TO_{it}}$ = (+ve)+(+ve)DT => $\frac{\partial INF_{it}}{\partial TO_{it}} > 0$

=(-ve)+(-ve)DT => $\frac{\partial INF_{it}}{\partial TO_{it}} < 0$

Or

= (+ve) +(-ve) => $\frac{\partial INF_{it}}{\partial TO_{it}} < 0$ or > 0 depending on DT.

=(-ve) +(+ve) =>

To find the threshold level of DT where the derivatives of the effect change, we apply the first order condition for optimization on equation (3.3) as follows;

$$\frac{\partial INF_{it}}{\partial TO_{it}} = \beta_{2+}\beta_4 DT_{it} = 0$$

$$=> DT^* = -\frac{\beta_2}{\beta_4}$$ where DT^* is a threshold.

This threshold value determines the effect of TO on INF, whether it is positive or negative. Figure 3.2 illustrates this effect; it is also explained below.

Case I

$DT > DT^*$

$$\frac{\partial INF_{it}}{\partial TO_{it}} < 0 \text{ or } > 0$$

OR

Case II

$DT < DT^*$

$$\frac{\partial INF_{it}}{\partial TO_{it}} < 0 \text{ or } > 0$$

Estimation Technique

The present study is based on panel data from a heterogeneous group of countries, which applies the Generalized Method of Moments (GMM) due to the dynamic nature of the model. However, GMM remains an effective and powerful technique to solve endogeneity issues, especially in dynamic models with lagged dependent variables. It works well with panel data, where problems arise from time-specific effects and unobserved heterogeneity. Since GMM applies both fixed effects (lower limit) and pooling effects (upper limit) before applying difference GMM, we selected it by following all the procedures. As a result, the system GMM is moved since the difference in GMM results falls below the lower and upper limits.

Moreover, GMM's ability to address endogeneity issues and handle dynamic panel data makes it ideal for this context. In macroeconomic models, endogeneity is common and arises when the dependent variable or missing variables affect the explanatory variables. By employing lagged values as instruments, GMM addresses this issue and produces estimates that are more reliable and unbiased. There are various benefits to this method. The procedure of estimating is systematically efficient. Heteroscedastic-consistent estimations and serial correlation are provided. It can also be

adjusted according to various model kinds and requirements (Arellano and Bond 1991; Arellano and Bover 1995).

Lagged dependent variables must also be included due to the dynamic nature of INF, where previous rates affect future rates. If these variables are not appropriately instrumented, bias may be introduced. In this situation, Blundell and Bond's (1998) system GMM approach is especially useful since it makes use of both lagged levels and lagged differences as tools, providing effectiveness even for variables that are persistent, like INF or trade indicators.

Diagnostics Test

The study conducted two diagnostic tests to ensure the model estimations are accurate and valid. The first test, the Arellano–Bond test for serial correlation, assesses whether serial correlation exists in the residuals of the dynamic panel model. The null hypothesis that there is no first-order serial correlation must be rejected to guarantee that the null hypothesis that there is no second-order serial correlation is accepted (Arellano and Bond, 1991). The second test, Hansen J, assesses how reliable the Generalized Method of Moments (GMM) technique's over-identifying limits are. According to Hansen (1982), the null hypothesis postulates that the instrument and error term are uncorrelated.

Results and Discussion

Descriptive statistics

The average rate of INF is 9.75%. However, the standard deviation is 78.12% and it reaches a maximum of 4145.11%, indicating substantial fluctuation. For example, the 1996 INF rate in Angola showed hyperinflation, while the 2009 inflation rate in Lesotho showed deflation at a minimum of 16.86%. And the CV is greater than 1, which means a high variation CV of this variable, then INF fluctuates greatly over time and is highly unstable. The mean value of TO is 85.19%, while the standard deviation is 52.37%. The lowest TO (0.03%) is recorded in 1996 in Iraq, while the highest value (442.62%) is recorded in Hong Kong SAR, China, in 2013. When the CV is less than 1, it indicates that TO is stable. Trade policy is more stable, and the country trades continuously.

Table 3: Statistical summary

Variable	Obs.	Mean	SD	CV	Min	Max
Inflation Rate (%)	3304	9.753739	78.12479	8.00972	-16.8597	4145.11
Trade Openness (%)	3304	85.19354	52.36771	0.61469	0.0269	442.62
Digitalization $_{norm}$(%)	3304	38.89006	35.50035	0.91284	0.0000	100.0000
GDP per capita growth (%)	3304	2.256494	6.366536	2.82143	-55.2289	140.491
Broad money (%)	3304	58.697	47.83408	0.81493	0.0145	461.6074
Interest Rate (%)	3304	13.89656	13.17224	0.94788	0.0000	291.06

Exchange Rate (%)	3304	0.8456297	15.44098	18.25974	0.0000	755.865

Table 3: Correlation Matrix

Variables	INF	TO	DT	GDPpc	BM	INT	EX
INF	1.0000						
TO	-0.0072***	1.0000					
DT	-0.0489**	0.1196	1.0000				
GDPpc	-0.0103**	0.0769*	-0.1000	1.0000			
BM	-0.0508*	0.4082	0.4064	-0.0888*	1.0000		
INT	0.4058	-0.1368	-0.0027***	-0.2942	-0.2942	1.0000	
EX	0.0284**	0.0177**	0.0164**	-0.0233**	-0.0233**	0.0780*	1.0000

Note: Take one dependent variable and six explanatory variables on both sides, i.e., vertical and horizontal. The various indicators employed in the panel data analysis. Where (***) Correlation is significant at the 1%, (**) at the 5% (*) and the 10%.

The dependent and independent variables' correlation analysis, is shown in Table 3, reveals that INF and TO are significantly correlated negatively (-0.0072). Similarly, INF and digitalization have a negative and significant (-0.0489) correlation. The relationship between INF and GDP per capita is significantly negative (-0.0103). Moreover, INF has a significantly negative (-0.0508) correlation with broad money. Then, INF has an insignificantly positive (0.4058) correlation with the interest rate. Finally, the analysis revealed a positive and significant (0.0284) association between the ER and INF. However, no correlation is high enough to create the problem of high multicollinearity.

Estimation Result

Since the econometric model used in the present study is a dynamic panel model, therefore most appropriate and well-known System GMM is a dynamic panel data estimation technique. To this end, the study is constrained statistically to focus on using, discussing, and interpreting the empirical results estimated through the system GMM for both models.

Table 4: Results of System GMM estimation

VARIABLES	MODEL 1	MODEL 2
Lag Inflation rate (annual %)	0.1526*	0.10991***
	(0.063)	(0.002)
Trade Openness (% of GDP)	2.2437***	-3.36605**
	(0.007)	(0.045)
Digitalization (% of population)	11.9590***	-5.71164**
	(0.002)	(0.025)
Trade Openness*Digitalization (%)	----------	0.070473**
		(0.021)

Interest Rate (% per annum)	4.4073**	1.11080
	(0.010)	(0.112)
GDP Per Capita Growth (annual %)	-71.4608***	-8.4926***
	(0.000)	(0.002)
Broad Money (% of GDP)	-5.7091***	-0.56878
	(0.002)	(0.213)
Exchange Rate (%)	9.4460	-7.50304
	(0.767)	(0.624)
Observations	3304	3304
Instruments	9	18
AR (2)	0.316	0.356
Sargan test	0.960	0.883
Hansen test	0.829	0.194

Note: While (**) and (*) indicate significance at the 5% and 10% levels, respectively, (***) denotes significance at the 1% level.

The test known as AR (2) is used to determine whether the residuals exhibit second-order autocorrelation. Sargan is a test to verify the validity of instruments, and Hansen is a test to over-identify limitations for instruments. Values in the parentheses are p-values. The appendix contains reports on additional regression statistics.

Interpretation and Discussion

Using the System GMM estimator, the study examines how TO affects INF and the influence of digitalization, addressing potential endogeneity and dynamic relationships. Firstly, it explains the base model (model 1), and secondly, it explains the interaction between two variables (TO and digitalization) in model 2.

Model 1

The lagged dependent variable's coefficient in model 1 (0.1526) is positive and statistically significant at the 10% level of significance p-value is 0.063, suggesting that INF is persistent. On average, a 1 percent increase in the lag INF rate is associated with a 0.1526 percent increase in current INF, holding all else constant. The TO coefficient (2.2437) is positive and significant at the 1% level of significance, with a p-value of 0.007, indicating a relationship between higher INF and more openness. The result indicates that, on average, a 1 percent increase in TO corresponds to a 2.2437 percent increase in INF, assuming all other factors remain constant. The finding of the present study shows that Romer's (1993) hypothesis does not apply to these economies. TO can reduce INF, according to the Romer hypothesis, by increasing production efficiency, allocating

resources optimally, and stabilizing domestic prices. Usually, a nation's increased TO lowers INF since competition rises and imported goods might become more affordable. But for the D-8 countries (Turkey, Nigeria, Pakistan, Bangladesh, Egypt, Indonesia, Iran, and Malaysia), TO and INF are positively correlated, i.e., greater TO results in higher INF. Because in D-8 nations with a lack of domestic market competition and price instability, TO may increase INF, while the fact that it usually assists in maintaining prices high (Sepehrivand and Azizi, 2016). According to Munir et al. (2015), they reject Romer's (1993) hypothesis for the chosen Asian nations. Romer claims that more open economies typically have lower INF. Romer basically made the case that TO forces monetary policy to be disciplined by outside forces, which in turn helps to maintain price stability. The research showed no reduction in INF as a result of monetary policies. Strict monetary laws alone, they contend, are insufficient to manage INF in nations with weak institutions and structural issues. However, the findings of the present study in Model 1 also do not support Romer's theory. In eight small open Caribbean economies, Thomas (2012) examined the connection between TO and INF. In contrast to Romer's assertion, the analysis revealed a positive correlation between TO and INF. The study's conclusions demonstrate that the Caribbean is vulnerable to external shocks and that inflationary imports have a negative impact on local prices.

The digitalization coefficient is 11.9590, which, at the 1% significance level, is both positive and significant, p-value is 0.002, suggesting that higher digitalization is associated with higher inflation. This indicates that, on average, a 1 percent increase in digitalization corresponds to an 11.9590 percent increase in INF, keeping other variables constant.

However, Setiawan et al. (2024) examined how digitalization affects INF in Indonesia. It finds that electronic money and card payments have a positive impact on INF, which is in line with the quantity theory of money. Therefore, inflationary pressures have been linked to the digitalization of the financial sector in Indonesia, especially through non-cash payment methods, including electronic money and card payments. The quantity theory of money explains this, showing that bigger transaction volumes can result in higher INF. Evidence suggests that, depending on the context and level of digital penetration, digitalization can have both inflationary and deflationary effects. As shown in Indonesia, where electronic money and card payments had a beneficial impact on INF, digitalization can initially induce inflationary pressures in emerging nations since it increases transaction volumes and the money supply. The interest rate's coefficient is 4.4073, the correlation between IR and INF is positive and statistically significant at the 5% level of significance, as indicated by the p-value of 0.010. This suggests that, on average, a 1 percent increase in the IR is associated with a 4.4073 percent increase in INF, assuming all other factors remain constant. Previous studies have shown that IR and INF are positively correlated (Amaefula, 2016; Mirza and Rashidi, 2018; Dritsaki, 2017). The GDP per capita growth coefficient is -71.4608, and it shows a high negative correlation with inflation (p-value = 0.000), statistically significant at the 1% level of significance. This suggests that, holding other factors constant, a 1 percent increase in GDP per capita growth is associated with an average reduction in the INF rate by approximately 71.4608 percentage points. This result is consistent with the results of (Ahmmed et al., 2020; Munyeka, 2014). Results have shown that INF and EG are negatively correlated. The Broad Money coefficient is -5.7091, and It shows a negative correlation with INF and is statistically significant at

the 1% level of significance (p-value = 0.002). This implies that, holding other variables constant, a 1 percent increase in Broad Money growth is associated with an average decrease in the INF rate by approximately 5.7091 percentage points. Therefore, studies have shown that broad money and INF are negatively correlated (Mbongo et al., 2014).

Model 2

After examining the individual effect of TO on INF, the present study extends the model by adding an interaction term between the two variables (TO and DT). This interaction term aims to determine whether the level of digitalization affects how TO affects INF. Thus, it is expected that digitalization will have a moderating effect on INF, either increasing or decreasing TO. The interaction term connecting digitalization and TO has a coefficient of 0.0705, indicating that it has a statistically significant and positive moderating influence on INF. The result shows that the inflation-reducing impact of TO becomes weaker as digitalization increases. TO and digitalization are directly associated with lower INF; their interaction is associated with higher INF. Both direct and indirect effects of TO on INF can be understood by threshold analysis. With all other factors held constant, an average increase of 1 percent in the interaction term (digitalization*trade openness) results in an increase of 0.0705 percent in INF. Parsi (2024) showed relationship between INF and TO has both positive and negative effects. Prasetyo and Yulinda (2024) examine and evaluate how TO and ICT indicators affect the INF rate in Asia following the global financial crisis. Results showed mixed (positive or negative) effects on INF and used different variables of the ICT (internet proxies). The GDP per capita growth coefficient is –8.4926, showing a statistically significant negative correlation with INF. This implies that if all other factors remain constant, a 1% rise in GDP per capita growth is associated with an average reduction in INF by approximately 8.49 percentage points (Ahmmed et al., 2020; Švigir and Miloš, 2017; Munyeka, 2014). Consequently, there is evidence that trade openness has an impact on INF in both positive and adverse directions. This could be understood in the presence of a digitalization threshold

Table 5: Marginal Effect of Trade openness on Inflation at Mean, Min, and Max values of DT

Digitalization	$\frac{\partial INF_{it}}{\partial TO_{it}} = \beta_2 + \beta_4 DT_{it}$ $= -3.37 + 0.0705\, DT_{it}$
MEAN(39.006)	=-3.37+0.0705 (Mean) =-3.37+0.0705(39.006)= - 0.62
MIN(0.0000)	=-3.37+0.0705(Min) =-3.37+0.0705(0.0000)= -3.37
MAX (100.00)	=-3.37+0.0705(Max) =-3.37+0.0705(100.00) = +3.68

Table 5 shows that $\frac{\partial \mathrm{INF}_{it}}{\partial \mathrm{TO}_{it}} < 0$ because the mean and minimum values are less than the threshold value. Whereas the maximum value is greater than the threshold value, therefore $\frac{\partial \mathrm{INF}_{it}}{\partial \mathrm{TO}_{it}}$ is positive. Since the mean is below the threshold value (47.8), the overall impact of trade openness (TO) on inflation (INF) is negative. It means TO is disinflationary in the presence of DT.

Conclusion and Policy Recommendations

The current study examines the moderating effect of digitalization while empirically analyzing the relationship between TO and INF. This study utilizes balanced panel data from 1996 to 2023 to explore the relationship between TO and INF via the digitalization channel. It employs the system GMM method to determine the effect of TO on INF and estimate the threshold level of digitalization for the heterogeneous income group of countries. The study tests both the direct and indirect impact to achieve its objectives. Overall, this research investigates the direct and indirect impact of trade openness on inflation.

Empirical findings clearly show that TO positively and significantly affects INF in Model 1 (without interaction between trade openness and digitalization), which is consistent with existing literature on INF if a country imports goods from high-inflation economies, higher openness means external inflation gets transmitted inside. So, positive effects often appear in developing or import-dependent countries where openness exposes the economy to external price shocks, weak policy frameworks, and structural rigidities instead of delivering competitiveness and efficiency (Sepehrivand and Azizi, 2016; Munir et al., 2015; Thomas, 2012). It indicates that a lack of competitiveness and inflationary imports cause INF as TO rises. Similarly, INF is positively and significantly impacted by digitalization, showing that as the economy becomes more digitalized, inflationary pressures are created.

Furthermore, it is important to analyze the indirect effects of TO on INF, as the main goal is to examine these indirect effects. The results in Model 2 (which includes the interaction between trade openness and digitalization) clearly show that TO has a negative and significant indirect impact on INF via digitalization. When studies find a negative impact of trade openness on inflation, it usually matches theory (Romer, 1993). The main logic is that opening up the economy to international markets increases competition, efficiency, and discipline, which reduces inflationary pressures (Parsi, 2024; Prasetyo and Yulinda, 2024).

They conclude that there is a direct and positive impact of TO on INF in our panel data, but an indirect relationship becomes negative in the presence of digitalization. This conclusion is based on the sign of the coefficient for the interaction term (trade openness and digitalization). Trade openness can influence inflation in both directions, depending on country-specific conditions. In many cases, openness exerts a negative effect on inflation by fostering import competition, lowering production costs through access to cheaper goods, promoting productivity gains, and encouraging governments to adopt disciplined monetary and fiscal policies to maintain exchange rate stability. However, in some contexts, trade openness has a positive effect on inflation, particularly in

developing or import-dependent economies. This occurs when openness exposes the economy to imported inflation, exchange rate volatility, and global price shocks, or when rising export revenues fuel demand that outpaces domestic supply. Weak institutional and policy frameworks can further amplify these inflationary pressures. Thus, the relationship between trade openness and inflation is not universal but rather depends on trade structure, exchange rate stability, and the strength of domestic institutions. The study resolves the puzzle that Romer's hypothesis applies to some countries but not others. This is clarified by including the interaction term between digitalization and TO. It suggests that Romer's hypothesis holds for countries where DT is below its threshold value and does not hold when DT exceeds that threshold.

Policy recommendation

The study provides recommendations based on the results from the analysis in the previous chapter. Our findings demonstrate a positive direct effect of TO and digitalization on INF. TO and digitalization are important determinants of inflation, and increasing TO and digitalization generate an inflationary effect due to imported inflation, weak domestic competition, and digitalization. These factors lead to increased demand, incur new costs for businesses, and cause money flows to accelerate.

Furthermore, it is important to analyze the indirect effects of TO and digitalization on INF because our main goal is to examine the indirect influence of digitalization as a moderating variable on inflation. However, an indirect relationship turns negative when digitalization is present. TO alone does not guarantee INF control, and digitalization by itself is not a sufficient anti-inflationary tool.

According to this interaction, trade and digitalization separately may increase INF (possibly through price transmission, cost channels, or demand shocks), but when combined, they can lower INF by improving productivity, price transparency, and supply chain efficiency.

- Policymakers should manage price transmission, cost channels, or demand shocks when combined (Trade openness*Digitalization); they can also lower INF through different mechanisms. To mitigate the potential inflationary effects of TO, policymakers should carefully monitor INF rates and adjust monetary policy as needed.

- Policymakers should consider the level of digitalization when designing targeted policies to manage TO on INF.

In this situation, governments may focus on implementing plans to promote digitalization across different income groups. This can be achieved by funding digital infrastructure, offering education and training programs, encouraging private sector investment in digital technology, and creating regulations that support digital innovation and entrepreneurship. By adopting these measures, countries with various income levels may be able to bridge the digital divide and benefit from increased access to services, enhanced competitiveness, and economic growth.

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