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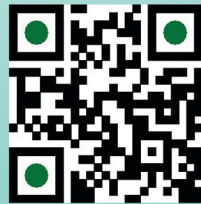
(Periodical - Scientific – Refereed)

Published by Saudi Economic Association

King Saud University

Volume 18, Issue No. 1

June 2026AD - Dhulhijjah, 1447H



Journal Website



Open Journal
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E-ISSN
1658 - 9998



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E-ISSN: 1658-9998▶ *Deposit No. 16811/1445*
P-ISSN: 2676 – 2684▶ *Deposit No. 142/1446*

Journal of Economic Studies

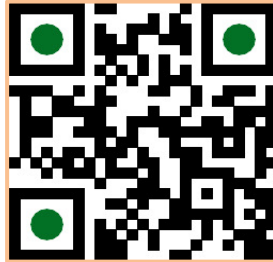
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English Section

The Impact of Structural Change on Carbon Dioxide Emissions: Further Investigation for GCC Countries ¹

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(Received: August 28, 2024; accepted for publication: October 20, 2024)

Abstract: Structural change plays a crucial role in GCC countries, influencing economic development and impacting CO₂ emissions and pollution levels. Efforts to diversify the economy aim to reduce dependence on oil and gas. This includes promoting renewable energy, investing in infrastructure, and developing service sectors such as education, health, tourism, and trade. These changes often enhance energy efficiency, leading to lower emissions. The main objective of this study is to analyze the impact of structural change and other variables, including energy consumption, economic growth (GDP), population, and globalization, on CO₂ emissions in GCC countries from 2003 to 2021. We employed the PMG-ARDL approach using panel data to investigate these relationships. Our findings reveal that, in the long term, CO₂ emissions in the GCC countries are significantly affected by economic growth (GDP), population growth, energy consumption, and globalization. In contrast, structural change significantly contributes to reducing these emissions. These results have important implications for policy-making in GCC countries, suggesting that sustainable development strategies should focus on integrating environmental considerations, particularly by promoting structural changes that enhance energy efficiency and reduce emissions.

Keywords: CO₂ Emissions, Structural Change, GCC Countries, Panel data, ARDL-PMG.

JEL Classifications: C33, F64, O53, Q56, L52, O13

1. Introduction.

Structural change is crucial to economic development and growth, and it is also critical for influencing CO₂ emissions. The effect of structural change on CO₂ emissions is affected by several factors, including the type of transition process, the energy intensity of production, and the quality of environmental policies. Indeed, although structural change can create chances to reduce CO₂ emissions, it can also cause environmental problems if

not managed well (Marra et al. (2024), Adebayo et al. (2022), Onanuga et al. (2021)). On one hand, it can lower emissions by helping the shift to cleaner sectors, like services, because, in terms of energy consumption, the energy intensity of the service sector is normally lower than that of the manufacturing sector (Shironitta, 2016). It can also promote new industries that use more efficient and less energy-consuming technologies (Bai et al., 2021). When paired with policies that

¹ **Acknowledgment:** This research was funded by the General Directorate of Scientific Research & Innovation, Dar Al Uloom University, through the Scientific Publishing Funding Program.

support renewable energy, structural change can further reduce CO₂ emissions (Fan et al., 2023). On the other hand, structural change can increase CO₂ emissions if it focuses on dirtier industries, like manufacturing and resource extraction. Rapid urbanization, caused by people moving to cities where new industries are located, can raise energy use in transportation and buildings. Additionally, if structural change depends on fossil fuels and does not incorporate renewable energy options, along with weak environmental policies, CO₂ emissions may increase rather than decrease (Li et al., 2019; Zhao et al., 2022). The abundance of oil resources in GCC countries significantly affects the manufacturing structure thereby influencing CO₂ emissions. For this reason, our purpose in this study is to investigate the long-term effect of structural change on CO₂ emissions and environmental pollution in the GCC² countries. We use panel data from 2003 to 2021 and employ the ARDL-PMG approach.

The key questions guiding our study are:

- What are the effects of structural change on the GCC countries between 2001 and 2021?

- How does structural change impact CO₂ emissions in these nations?

- How do policies related to structural change influence CO₂ emissions, and what strategies can be adopted to mitigate this environmental impact?

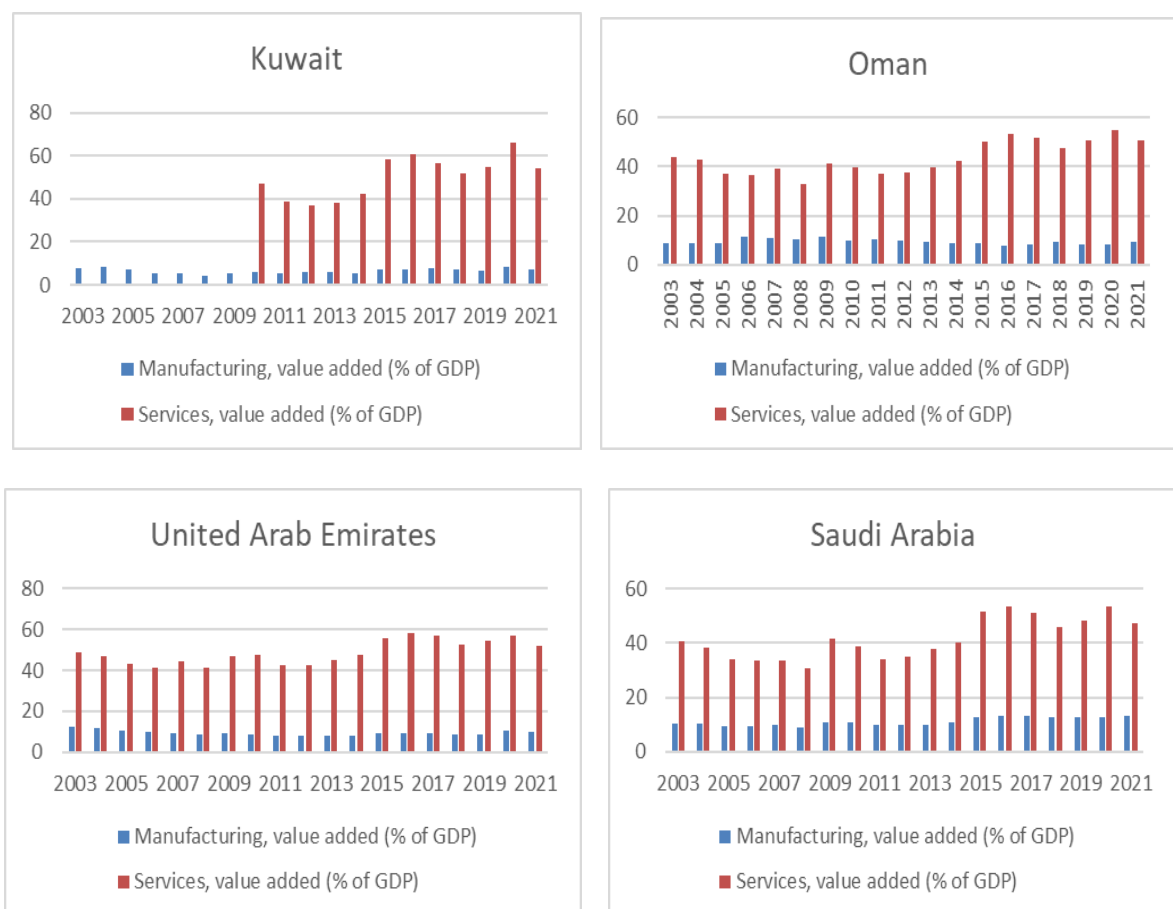
The relevance of this study stems from the distinct economic and environmental characteristics of the GCC countries. On one hand, these countries have abundant reserves of oil, natural gas, and other energy resources. This creates

strong connections between structural change and extractive industries, which are significant sources of CO₂ emissions. On the other hand, GCC countries have invested in renewable energy to diversify their energy portfolios and have implemented various environmental policies.

Over the past two decades, GCC countries have seen an increasing diversification of their economies towards the service sector and renewable energy. This shift is driven by different policies and strategies aimed at economic growth. Several service sectors are growing quickly, such as tourism and hospitality, and health, to meet rising demand. The education sector is also growing, with new universities and the rise of international institutions and vocational training programs. At the same time, the GCC countries have invested heavily in information and communication technologies (ICT) and have developed and diversified their financial services amid the rise of fintech and digital banking. These efforts have helped the service sector grow, often at the expense of the manufacturing sector in the region, which has had an effect on the reduction of CO₂ emissions and the improvement of the environment. The following Charts, based on World Bank data (WDI 2023), show a clear structural change toward the service sector in GCC countries. The share of value added by the service sector in GDP steadily increased from 2003 to 2021. This trend indicates economic diversification in favor of this sector, which is less energy-intensive, especially in non-renewable resources, and implies a decrease in dependence on oil, a major source of CO₂ emissions. This shift toward the service sector in GCC countries is likely to have negative effects on CO₂ emissions.

² Saudi Arabia, Kuwait, the United Arab Emirates, Qatar, and Oman.

Chart 1: Shares of the added value of the service and manufacturing sectors in GDP.



The rest of the paper is organized as follows: in the literature review section, we summarize the results of several studies that have examined the effects of structural change on CO2 emissions across different regions and countries. The third section presents the data and describes the empirical methodology. In the fourth section, we present and discuss the results. Finally, in the fifth section, we summarise the main results and offer policy recommendations.

2. Literature review.

The economic literature shows controversy regarding the relationship between structural change and CO2 emissions. Some studies find positive effects, while others find negative effects. Indeed, Marra et al. (2024) used a PVAR model to study the direct effects of structural and technological change and

their interaction on CO2 emissions. They analyzed panel data from 34 OECD countries and a group of countries with significant trends in energy intensity from 1994 to 2019. The results indicate that technological change effectively reduces CO2 emissions. However, the direct effect of structural change does not lead to emissions reductions on its own; instead, its interaction with technological change contributes to lower CO2 emissions and energy intensity.

Also, Pata et al. (2024) used two long-term estimators, namely rCCE and AMG, to illustrate that structural change plays a significant role in reducing CO2 emissions in BRICS countries between 2000 and 2022. Dong et al. (2020) used panel data from 41 countries to examine the effects of GDP, structural change, urbanization, technology, and trade openness on CO2 emissions. Their

empirical results show that structural change negatively and significantly affects CO₂ emissions. Adebayo et al. (2022) utilized the NARDL model to estimate the asymmetric effects of structural change, GDP, and the consumption of renewable and non-renewable energy on CO₂ emissions in Turkey between 1965 and 2019. Their results reveal that structural change hurts CO₂ emissions. However, this effect is not sustainable, largely due to Turkey's dependence on fossil fuels and its economic activity.

Shironitta (2016) studied the effect of structural change on CO₂ emissions using panel data from 40 countries between 1995 and 2009. The structural change is measured by two variables: industrial composition and the use of advanced technologies in each country. The author compares the impact of structural change on CO₂ emissions in high-income countries and middle-income countries. The results indicate that in high-income countries, CO₂ emissions decrease industries as the economy shifts from manufacturing to services. In contrast, in middle-income countries, CO₂ emissions increase due to rapid industrial growth. Additionally, improvements in domestic technology helped reduce CO₂ emissions in both high- and middle-income countries. Onanuga et al. (2021) use a PMG approach to investigate how changes in the agricultural and industrial sectors influence CO₂ emissions in 31 Sub-Saharan African countries from 1990 to 2017. The findings indicate a positive relationship between structural change and CO₂ emissions, driven by the industrialization process and the lack of adequate environmental protection.

Since China has adopted environmental policies aimed at shifting from energy-intensive to low-energy industries to reduce CO₂ emissions, several studies have examined the effects of structural change on CO₂ emissions in China, using panel data across provinces

and over different periods. Most of these studies concluded that structural change that leads to a reduction in energy intensity within the manufacturing sector is associated with decreased CO₂ emissions. Indeed, Bai et al. (2021) examine the relationship between structural change (industrial restructuring), CO₂ emissions, economic growth, and employment in China from 2010 to 2018. Their findings show that structural change can reduce CO₂ emissions by decreasing output in high-emission sectors. However, this reduction often comes with economic costs, including possible job losses. Also, Liu, Shi, and Huang (2022) used a Stochastic model to study the impact of industrial restructuring and to assess the effects of industrial structure adjustments on CO₂ emissions in China using panel data from 57 cities over the period 2009-2019. The results show that progress in China's industrial structures harms CO₂ emissions.

Fan et al. (2023) also examined the impact of modernizing industrial and energy structures on CO₂ emissions in China, using panel data from 30 provinces covering the period from 1997 to 2019. The results indicate that both the modernization of industrial structure and the optimization of energy structure directly contribute to reducing CO₂ emissions, with notable regional differences among the provinces. Additionally, the findings reveal that the interaction between industrial modernization and energy optimization further enhances the reduction of CO₂ emissions. These results are consistent with the studies by Li et al. (2019) and Zhao et al (2022), who showed that while improving the manufacturing structure contributes to reducing CO₂ emissions in China, this effect is constrained by each province's reliance on natural resources.

According to Jiang et al. (2020), since 2011, structural change and a slowdown in economic growth in China have played a greater role in reducing CO₂

emissions than the effect of renewable energy development. The results of these studies on China emphasize the significance of its strategy to reduce emissions intensity by 60 to 65% by 2030 compared to 2005 levels and to achieve carbon neutrality by 2060. Adebayo et al. (2023) employed a Nonlinear Auto-Regressive Distributed Lag (NARDL) model to investigate the asymmetric effects of structural change and energy structure optimization on CO₂ emissions in Turkey from 1965 to 2019. Their findings indicate that both structural change and energy optimization reduce CO₂ emissions.

Udeagha and Ngepah (2022) used the quantile distributed autoregressive (QARDL) method to study how technological innovation affects CO₂ emissions in South Africa from 1960 to 2020. They identified two effects on CO₂ emissions: the scale effect, which results from increased production activity, and the technical effect, which comes from improved technologies. The results show that technological improvements help reduce CO₂ emissions in both the short and long term, while the scale effect leads to higher emissions. This finding supports Kuznets' hypothesis, which suggests that economic growth may initially increase CO₂ emissions, but technological advances can later reduce them. Ueda (2022) conducted a structural decomposition analysis (SDA) to study Japan's energy transitions and CO₂ emissions from 2005 to 2015. This method isolates the impact of structural change on CO₂ emissions from other factors. The results show that after 2011, structural change in Japan became the main driver of CO₂ emissions reductions in the manufacturing and service sectors. This is mainly due to technological innovations in energy and renewable sources.

Jung et al (2000) examined the impact of the structural composition of the manufacturing sector on CO₂ emissions in Korea from 1981 to 1996. To isolate the

effects of structural change on CO₂ emissions, the authors employed a sectoral decomposition method, specifically, energy intensity decomposition. The results indicate that the decline in energy intensity structural changes in industry, significantly contributed to CO₂ emissions. In three different studies, Ali et al. (2020, 2021, 2022) examined the short and long-term effects of structural change and other factors (GDP, globalization, trade, energy consumption) on CO₂ emissions in Pakistan. They used a variety of methods, including ARDL and DOLS, over different periods. Structural change was measured by several indicators, including sectoral growth in the service sector (including tourism) and agriculture. The results of these studies are as follows: The 2020 study shows that industrial growth significantly increases CO₂ emissions. In contrast, growth in the service sector helps reduce CO₂ emissions. Agricultural growth also reduces CO₂ emissions, but this effect is not significant. In the short term, growth in the industrial, agricultural, and service sectors all contribute to reducing CO₂ emissions. The 2021 study found that structural change and trade have no significant effect on CO₂ emissions. It also showed that tourism activities are environmentally friendly. The 2022 study showed that structural changes are detrimental to environmental quality.

Overall, while various studies have its impact in GCC countries. Most studies focus on other factors, such as economic growth (GDP), energy use (both renewable and non-renewable), financial development, trade openness, and urbanization. This is important because GCC countries are now working to diversify their economies and develop sectors beyond oil. This gap in the research shows the need to study how these economic changes impact CO₂ emissions in the unique context of the GCC.

3. Data and methodology.

3.1. Data

Our goal in this paper is to examine the relationship between CO₂ emissions (the dependent variable) and structural change, energy consumption, economic growth (GDP), population, and globalization in the Gulf Cooperation Council (GCC) countries from 2003 to 2021.

- *CO₂ emissions*, which are increasing yearly, are a key indicator of environmental pollution. The main sources of CO₂ emissions are the combustion of coal, natural gas, oil, and other fuels, which harm the environment. CO₂ emissions are measured in millions of metric tons (MMt), while energy consumption is expressed in quadrillion British thermal units (Q Btu). Data for both variables are collected from the U.S. Energy Information Administration (EIA) database (2023).

Structural change: According to CNUCED, "Structural Change: Structural change refers to the movement of labor and other productive resources from low-productivity to high-productivity economic activities. This shift is currently captured by the sophistication and variety of exports, the intensity of fixed capital, and the share of industry and services in total GDP. Structural change can also happen within a given sector, provided that binding constraints in the sector are identified and effectively addressed". The effect of structural change on the choice polluting sectors is likely to influence CO₂ emissions. By directing resources and labor toward more sustainable industries, it is possible to significantly reduce carbon emissions and promote environmental protection.

-*Gross Domestic Product (GDP)* is an indicator of economic growth; its values are expressed in trillions of dollars, adjusted for purchasing power parity (PPP), and reported in 2015 dollars. GDP is a major source of CO₂ emissions because economic growth is connected to industrialization. This leads to increased energy use, primarily from non-renewable sources such as coal, oil, and natural gas. As countries try to increase their GDP, they build more industries and infrastructure, which means they depend more on fossil fuels. This results in higher carbon emissions.

-*Population* can significantly affect CO₂ emissions. Generally, countries with larger populations tend to consume more energy, which often results in higher CO₂ emissions.

GDP and population data are collected from the World Development Indicators (WDI) database (2023). Data on globalization are collected from the KOF Swiss Economic Institute database (2021). -*Globalization: globalization affects CO₂ emissions because the increase of international trade with increasing industrialization* led to a rise in energy consumption and CO₂ emissions. According to the WTO report on international trade (2023), about 10% of global CO₂ emissions come from international trade. Data on globalization. Data on globalization are collected from the KOF Swiss Economic Institute database (2021).

Table 1 below summarises the symbols, measurement units, and sources for the various variables.

Table 1. Variables definition

Variables	Symbo l	unit of measurement	Sources
Carbon dioxide emissions	CO2	MM tonnes	EIA (2023)
Energy consumption	EC	QBTU	
Gross Domestic Product	GDP	constant 2015 USD	WDI(2023)
Population	Pop	Total number of inhabitants	WDI(2023)
Globalisation	GLOB	index	KOF Swiss Economic Institute (2021)
Structural change index	SCI	Index	UNCTAD (2024)

3.2. Methodology.

Our aim in this paper is to explore the long-run relationships between CO2 emissions (dependent variable) and the following independent variables: energy consumption, economic growth, population, globalization, and structural change. To achieve this, we adopted the following empirical model.

$$CO2_{it} = f(GDP_{it}, STCHG_{it}, EC_{it}, GLOB_{it}, POP_{it}) \quad (1)$$

CO₂, GDP, STCH, EC, GLOB, and POP represent carbon dioxide emissions (dependent variable), GDP, structural change, energy consumption, globalization, and population, respectively. (i) denotes country i and (t) denotes year t, since we use annual panel data.

Study Hypotheses.

Considering the economic realities of the GCC countries and drawing from existing literature, this study proposes the following hypotheses:

- Structural change is expected to lead to a reduction in CO₂ emissions.
- The economic growth (GDP) in GCC countries, heavily reliant on the oil and manufacturing sectors, is expected to be a significant source of CO₂ emissions.
- Population growth is likely to have a positive effect on CO₂ emissions in the region, as the arid and hot climate

increases energy consumption for air conditioning and transportation.

- Energy consumption is anticipated to positively influence CO₂ emissions due to the GCC's strong dependence on fossil fuels, particularly oil and natural gas, which are widely used in production, transportation, and industry. The region's abundant reserves of these resources make them easily accessible and economically viable.

- GlobalizationGlobalization is expected to contribute positively to CO₂ emissions, as increased economic and financial activities between the GCC countries and the rest of the world lead to higher pollution levels in the region.

3.2.1. Descriptive statistics.

Descriptive statistics provide an important summary of the data to understand the variability and distribution of variables over time and across GCC countries. As shown in Table 2, the average CO₂ emissions in GCC countries are 178.64 million metric tons (MMt), with a standard deviation of 171.14 MMt. This indicates considerable variation in CO₂ emissions across GCC countries, ranging from a minimum of 31.75 MMt to a maximum of 611.42 MMt. Similarly, there is a significant difference in GDP among the GCC countries. The average GDP exceeds the median, with a standard deviation of $2.03 * 10^{11}$. Moreover, the gap between the maximum value ($7.28 * 10^{11}$)

and the minimum value ($3.89 * 10^{10}$) is considerable. This disparity is largely because Saudi Arabia and the United Arab Emirates have higher GDPs than Kuwait, Qatar and Oman. We also observe a significant disparity between the GCC countries in terms of population. Saudi Arabia is the most populous country,

followed by the United Arab Emirates, Oman, Kuwait and finally Qatar, which has the smallest population among the five countries. This disparity influences energy consumption and consequently CO₂ emissions: More populous countries typically have higher energy demands, resulting in increased CO₂ emissions.

Table 2. Descriptive statistics.

Variables	CO ₂	GDP	EC	GLOB	POP	STCH
Mean	178.6380	2.41E+11	3.432091	66.58514	9339108.	57.48316
Median	96.12750	1.39E+11	1.913423	66.77913	4124904.	57.50000
Maxim	611.4230	7.28E+11	12.26795	76.96236	35997107	76.90000
Minim	31.75296	3.89E+10	0.400363	50.67226	748525.0	41.70000
Std.Dev.	171.1351	2.03E+11	3.300068	5.836173	10936992	7.789609

CO₂, GDP, EC, GLOB, POP, and STCH correspond to CO₂ emissions, real GDP, Energy Consumption, Population, and Structural Change

Similarly, the mean energy consumption (3.43 Q Btu) is higher than the median (1.91 Q Btu), and the maximum value is significantly greater than the minimum. This finding aligns with the understanding that economic growth (GDP) and population growth are key drivers of energy consumption.

3.2.2. Cross-sectional dependence (C-SD) test.

When analyzing panel data, it is essential to test cross-sectional dependence (C-SD) to assess the correlations among individual observations and ensure the reliability of the results. Cross-sectional dependence can significantly influence panel analysis outcomes by introducing bias and reducing estimation efficiency. In the empirical literature, various diagnostic tests are used, including the Breusch-Pagan Chi-square, Pearson LM Normal, Pearson CD Normal, Friedman Chi-square, and Frees Q tests. The null hypothesis for these tests assumes cross-sectional independence, meaning there are no significant correlations among the panel units. Conversely, the alternative

hypothesis indicates that mutual dependence is present within the panel. The results of the C-SD test, using the Pearson CD test, yield a t-statistic of 0.503594 with a p-value of 0.6145, confirming that the application of first-generation panel unit root tests (PURT) is both appropriate and well supported.

3.2.3. Panel unit root tests (PURT).

In the following section, we estimate the stationarity of the variables used in our empirical model. Our objective is to determine whether these variables are stable in the long term or exhibit non-stationary trends. Conducting unit root tests is crucial for obtaining reliable and unbiased results while minimizing specification errors. For this analysis, the well-known Augmented Dickey-Fuller (ADF, 1979) and Phillips-Perron (PP, 1988) unit root tests have been applied to

check the stationarity of the data series.³ The results, presented in Table 3, show that all variables are not stationary at the level, but become all stationary at the first difference. These findings enable us to

investigate the presence of long-run cointegration among the variables. Therefore, we will apply the Pedroni test to analyse this cointegration in the context of panel data.

Table 3. Panel Unit Root Tests (PURT)

	At level	lnCO2	lnGDP	EC	IPOP	lnGLOB	lnSTCH
ADF	t-Statistic	0.66421	5.35342	1.87999	14.5438	10.4218	13.0133
	Prob.	1.0000	0.8664	0.9972	0.1496	0.4043	0.2229
	First dif	d(lnCO2)	d(lnGDP)	d(EC)	d(lnPOP)	d(lnGLOB)	d(lnSTCH)
	t-Statistic	42.4152	31.9601	40.9459	34.5218	35.1637	29.6203
	Prob.	0.0000***	0.0004***	0.0000***	0.0002***	0.0001***	0.0010***
PP	At level	lnCO2	lnGDP	EC	lnPOP	lnGLOB	lnSTCH
	t-Statistic	3.66212	5.52617	1.41707	0.48902	12.0502	6.55947
	Prob.	0.9613	0.8534	0.9992	1.0000	0.2817	0.7663
	First dif	d(lnCO2)	d(lnGDP)	d(EC)	d(lnPOP)	d(lnGLOB)	d(lnSTCH)
	t-Statistic	71.5193	35.2595	62.416	1.987	48.9135	30.0184
	Prob.	0.0000***	0.0001***	0.0000***	0.0007***	0.0000***	0.0009***

“***” indicates statistical significance at the 1%. d(.) indicates the first difference.

3.2.4. Pedroni cointegration test results.

We used the seven cointegration tests of Pedroni (2001) to assess long-run cointegration between the dependent variable (CO2 emissions) and the independent variables. These tests are classified into two groups: intra-dimension and inter-dimension. The results are summarised in Table 4. In the intra-dimension panel, which includes four tests (Panel v, Panel rho, Panel PP, and Panel ADF), the Panel v and rho tests did not

confirm the presence of cointegration. On the other hand, the PP and ADF tests indicated significant cointegration. In the inter-dimension group, which includes three tests (Panel rho, Panel PP, and Panel ADF), the Panel rho test did not reject the null hypothesis of no cointegration. However, the Panel PP and ADF tests confirmed cointegration. Overall, four of the seven tests confirmed long-term cointegration between the variables, allowing us to affirm its existence and proceed with long-term estimations.

Table 4. Pedroni cointegration test results

	Panel (within-dimension)				Group (between-dimension)		
	Panel v-Statistic	Panel rho-Statistic	Panel PP-Statistic	Panel ADF-Statistic	Group rho-Statistic	Group PP-Statistic	Group ADF-Statistic
Statistic	-1.970725	2.45407	-1.435215*	-3.14350**	3.116301	-6.69504**	-2.88466**
Prob	0.9756	0.9929	0.0756	0.0008	0.9991	0.0000	0.0020

*, and ** indicates statistical significance at the 10% , 5% and 1 % level respectively.

³ First-generation tests for panel unit roots were conducted under the null hypothesis of no cross-

sectional dependence. The results indicate that this null hypothesis is not rejected.

4. Empirical Estimations results and discussion.

4.1. Model

We use the ARDL-PMG approach for these reasons. First, our Panel Unit Root Tests indicate that all variables are stationary at either I(0) or I(1), consistent with the assumptions of this model. Second, the ARDL-PMG model allows us to analyze both short-term and long-term effects, which helps us better understand

the relationships between the variables. Third, it works well with small sample sizes, making it ideal for our study of five countries. Finally, the ARDL-PMG model helps address problems such as endogeneity, heteroscedasticity, autocorrelation, and multicollinearity, which can affect the results.

We used the following specification of the panel ARDL (p, q) model.

$$\begin{aligned} \ln CO2_{it} = & +\alpha_i + \sum_{j=1}^{p-1} \beta_{1ij} \ln CO2_{it-j} + \sum_{j=0}^{q-1} \beta_{2ij} \ln GDP_{it-j} + \sum_{j=0}^{q-1} \beta_{3ij} STCHG_{it-j} \\ & + \sum_{j=0}^{q-1} \beta_{4ij} \ln EC_{it-j} + \sum_{j=0}^{q-1} \beta_{5ij} GLOB_{it-j} + \sum_{j=0}^{q-1} \beta_{6ij} \ln POP_{it-j} + \varepsilon_{it} \end{aligned} \quad (2)$$

Transforming variables to logarithmic form enables us to interpret the estimated coefficients as elasticities, making it easier to understand how CO2 emissions respond to changes in the

explanatory variables. According to the work of Pesaran et al. (1996, 2001), the equation (2) can be expressed in the following alternative form:

$$\begin{aligned} \Delta \ln CO2_{it} = & +\alpha_i + \partial_{1i} \ln CO2_{it-1} + \partial_{2i} \ln GDP_{it-1} + \partial_{3i} \ln STCHG_{it-1} + \partial_{4i} \ln EC_{it-1} \\ & + \partial_{5i} \ln GLOB_{it-1} + \partial_{6i} \ln POP_{it-1} + \sum_{j=1}^{p-1} \delta_{1ij} \Delta \ln CO2_{it-j} + \sum_{j=0}^{q-1} \delta_{2ij} \Delta \ln GDP_{it-j} \\ & + \sum_{j=0}^{q-1} \delta_{3ij} \Delta \ln STCHG_{it-j} + \sum_{j=0}^{q-1} \delta_{4ij} \Delta \ln EC_{it-j} + \sum_{j=0}^{q-1} \delta_{5ij} \Delta \ln GLOB_{it-j} \\ & + \sum_{j=0}^{q-1} \delta_{6ij} \Delta \ln POP_{it-j} + v_{it} \end{aligned} \quad (3)$$

In this equation, the terms in levels show long-run effects, while the terms in first differences show short-run effects. The coefficients ∂ni and δni ($n = 1 \dots 6$) represent the long-term and the short-term effects, respectively. These parameters indicate how CO2 emissions change for a one-unit change in each independent variable, holding all other variables constant. The term v_{it} is the error term, and Δ means the first difference operator.

4.2. Results and Discussion.

We mainly focus on the long-term effects of independent variables on CO2 emissions. The optimal lag length for the panel ARDL model is ARDL(1, 1, 1, 1, 1), as determined by the Schwarz Information Criterion (SIC). The findings in Table 5 reveal a positive and significant long-term relationship between GDP and CO2 emissions in the GCC countries. This relationship is because economic growth

drives energy consumption, especially in the industrial sector. Our findings align with several empirical studies that have similarly identified a positive and significant impact of GDP on CO2 emissions. (Aye et al., 2017, Muhammad, B., 2019), Islam et al. (2021), Sheraz et al. (2021), Zhang, T et al. (2023). Structural change has a significant negative effect on CO2 emissions. This effect is explained by

the policies adopted by GCC countries regarding economic and energy diversification, improvement of energy efficiency, strategies to promote a greener economy, transition to green services and technologies, and investments in renewable energy. These policies have allowed GCC countries to reduce their dependence on fossil fuels.

Table 5. ARDL-PMG estimates

Dependent variable: LCO2				
Long Run Results				
Variable	Coefficient	Std. Error	t-Statistic	Prob
LGDP	0.190406	0.076318	2.494885	0.0159**
EC	0.294309	0.037722	7.801994	0.0000***
LSTCH	-0.148567	0.087485	-1.698195	0.0957**
LGLOB	0.596733	0.345497	1.727171	0.0903**
LPOP	0.218015	0.057676	3.780012	0.0004***
ECT-1	-0.607530	0.182505	-3.328835	0.0016***

**** and *** indicates statistical significance at the 10% , 5% and 1 % level respectively.**

The results also reveal a significant and positive long-term impact of energy consumption on CO2 emissions. This effect is particularly pronounced in the GCC countries, where vast reserves of oil and natural gas are major contributors to CO2 emissions. The reliance on fossil fuels for energy not only meets high demand but also supports industrial growth, rapid urbanization, and cooling needs in a region characterized by extreme temperatures. These findings align with existing literature that similarly identifies a positive correlation between energy consumption and CO2 emissions. (Shafiei (2014), Bulut (2017), Bhat (2018), Inglesi-Lotz et al (2018), Zhang, Y. et al (2023). Zhang, T et al (2023). Population growth has a significant impact on long-term CO2 emissions. As the population rises, the demand for non-renewable energy sources, such as oil and gas, also increases to meet

the needs for housing, transportation, and consumption. Additionally, rapid urbanization and changing lifestyles, fueled by favorable economic conditions in the GCC, contribute to higher CO2 emissions due to increased energy use. (Khan et al. (2019), Le et al. (2020), Ivanovski et al. (2022), Islam et al. (2021), Gaies et al. (2022), Adebayo et al. (2023), Zhou et al. (2023)).

The effect of globalization on CO2 emissions in GCC countries is positive and significant. This result is consistent with other studies that have shown that globalisation contributes to CO2 emissions (Khan et al (2019), Ivanovski et al (2022), Islam et al (2021), Gaies et al (2022), Adebayo et al (2023)). This positive effect is due to increased trade and FDI flows with the GCC region. Indeed, these countries heavily export oil and natural gas

and import large quantities of consumer goods and equipment to satisfy mainly the demand of the production, construction, and transport sectors, which significantly contribute to CO₂ emissions. Furthermore, the economic and strategic importance of the GCC region has attracted foreign investment, particularly in energy-intensive industries such as the petrochemical industry, thereby further driving CO₂ emissions.

5. Conclusion and policy recommendations

In this study, we examined the long-term impact of GDP, structural change (key variable), energy consumption, population, and globalization on CO₂ emissions in the GCC countries. The results reveal that, in the long term, CO₂ emissions in the GCC countries are significantly affected by economic growth (GDP), population growth, energy consumption, and globalization. In contrast, structural change contributes to a reduction in these emissions.

According to these findings, a set of policy recommendations can be adopted to reduce CO₂ emissions and promote sustainable development in the GCC countries. First, since the GCC countries rely heavily on oil for growth and trade, to keep structural change effective in reducing CO₂ emissions, they need to diversify their economies more by investing in non-oil sectors such as technology, tourism, services, and renewable energy like solar, wind, and geothermal energy.

Second, it is also important to modernize economic structures and transportation infrastructure by cleaner

technologies, promoting public transport. Third, to maximize the benefits from structural change in reducing CO₂ emissions, GCC countries should implement economic incentives to support green investments in less polluting sectors and clean technologies. It is essential to establish strict environmental regulations and introduce more financial incentives and subsidies for energy-efficient technologies to encourage their adoption. Especially as Foreign Direct Investment (FDI) increasingly focuses on the energy sector, encouraging investment in less polluting sectors, such as tourism and services, can be facilitated by providing tax incentives.

Finally, it is important to implement education and training programs for green jobs and to promote circular economy practices. These strategies will improve sustainability and further reduce emissions.

Our study presents interesting findings but also has some limitations that suggest valuable directions for future research. First, it is important to examine the impact of specific policies that promote structural change and sustainability, such as economic diversification and energy efficiency programs. Second, comparing the GCC with other regions, such as the European Union or Southeast Asia, could provide useful insights into how structural change affects CO₂ emissions. Additionally, it is important to study the factors driving structural change, especially the role of renewable energy and how its growth affects the relationship between structural change and CO₂ emissions. Finally, it is necessary to use more advanced methods to predict future effects and evaluate the costs and benefits of these structural change policies.

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DOI: 10.33948/ESJ-KSU-18-1-4

تأثير التغيير الهيكلي على انبعاثات ثاني أكسيد الكربون: دراسة معمقة لدول مجلس التعاون الخليجي

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(قُدِّم للنشر: 28 أغسطس، 2024م - وقَبِل للنشر: 20 أكتوبر، 2024م)

المستخلص:

يلعب التغيير الهيكلي الاقتصادي دورًا حيويًا في دول مجلس التعاون الخليجي، حيث يؤثر بشكل مباشر على النمو الاقتصادي، التنمية الاقتصادية والتلوث من خلال انبعاثات ثاني أكسيد الكربون. وتهدف الجهود المبذولة من طرف دول مجلس التعاون الخليجي لتنويع الاقتصاد إلى التقليل من الاعتماد على النفط والغاز كمصادر رئيسية للطاقة، ويتضمن ذلك تعزيز الطاقة المتجددة، والاستثمار في البنية التحتية، وتطوير قطاعات الخدمات مثل التعليم والصحة والسياحة والتجارة وغيرها. غالبًا ما تؤدي مثل هذه التغييرات الهيكلية إلى تحسين كفاءة استعمال الطاقة، مما يسهم في تقليل التلوث وحماية البيئة. الهدف الأساسي لهذه الدراسة هو تحليل تأثير التغيير الهيكلي والتغيرات الأخرى، بما في ذلك استهلاك الطاقة، والنمو الاقتصادي (الناتج المحلي الإجمالي)، والسكان، والعمولة، على انبعاثات ثاني أكسيد الكربون في دول مجلس التعاون الخليجي من عام 2003 إلى عام 2021. ولتحقيق هذا الهدف، قمنا باستخدام منهجية PMG-ARDL وبيانات زمنية/مقطعية. تكشف نتائج هذه الدراسة أنه في المدى الطويل، تتأثر انبعاثات ثاني أكسيد الكربون في هذه الدول بشكل كبير بالنمو الاقتصادي (الناتج المحلي الإجمالي)، والنمو السكاني، واستهلاك الطاقة، والعمولة. في المقابل، يسهم التغيير الهيكلي بشكل ملحوظ في تقليل هذه الانبعاثات. تترتب على هذه النتائج آثار مهمة على مستوى السياسات الاقتصادية في دول مجلس التعاون الخليجي، مثل ضرورة تركيز استراتيجيات التنمية المستدامة على دمج الاعتبارات البيئية حيث ينبغي أن تتضمن هذه الاستراتيجيات تعزيز التغييرات الهيكلية التي تساهم في تحسين كفاءة الطاقة وتقليل الانبعاثات.

الكلمات المفتاحية: انبعاثات ثاني أكسيد الكربون، التغيير الهيكلي، دول مجلس التعاون الخليجي، بيانات زمنية/

مقطعية، ARDL-PMG.

The Impact of Banking Development on Economic Growth: Empirical Evidence from Egypt during the period 1990-2023

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(Received: July 10, 2025; accepted for publication: September 07, 2025)

Abstract: *This study investigates the impact of banking sector development on economic growth in Egypt from 1990 to 2023. Using the Autoregressive Distributed Lag (ARDL) model, the research assesses the long-term effects of advances in the banking sector on economic performance. Additionally, the study incorporates the Error Correction Model (ECM) to capture short-term dynamics and relationships. The findings reveal a significant positive impact of banking development on economic growth in the long run, while also indicating that short-term results are largely consistent with the long-term outcomes. These insights highlight policy measures to maximize the growth impact of banking development in Egypt. Key recommendations include strengthening private-sector participation, encouraging foreign bank entry, and adopting international standards for supervision and risk management. Enhancing customer protection, raising public awareness of banking services, and investing in human capital through training and professional certifications are also emphasized. Additionally, promoting trade openness, boosting export competitiveness, and controlling inflation are identified as crucial to reinforcing the banking–growth relationship.*

Keywords: *Banking Sector Development; Economic Growth; ARDL Model; Error Correction Model; Egyptian Economy.*

1. Introduction

Banking development is defined as a process of improvements in the quantity and efficiency of banking services (Pradhan et al., 2014). Consequently, it involves two dimensions: increasing the financial resources in the economy and directing these resources towards the most productive uses. The banking sector is an integral part of the Egyptian economy. As

in many emerging markets, banks in Egypt are the dominant financial institutions. They control most of the financial flows and possess most of the financial assets in Egypt. According to the financial stability report, the banking sector's assets represent about 92.6% of the financial system's total assets at the end of FY 2023 (CBE, 2023).

The Egyptian economy has suffered from low economic growth over the past few decades. The growth rate of real GDP per capita averaged about 2.27% between 1990 and 2023 (World Bank, 2024). This rate is considered low for a developing country. Economic literature identified different channels linking banking development and economic growth. These channels included the supply of investment credits, the provision of information, and the insurance of risks. These channels contribute to the accumulation of financial resources can be used, thereby increasing economic growth (Neimke, 2003).

The Egyptian banking sector was heavily repressed between 1960 and 1990; the government intervened and distorted its market mechanisms. The government set ceilings on nominal deposit and lending interest rates, imposed a relatively high required reserve ratio, determined the allocation of credit to particular projects, and intervened in banks' portfolio composition (Mohieldin et al., 2019). The Egyptian economy has witnessed a successive improvement in its banking sector since the economic reform program, which started in 1990 and included a financial liberalization policy by removing interest rate ceilings, reducing reserve requirements, and canceling direct credit programs to allow credit allocation to be determined by the free market (Hemaya et al., 2017).

This paper examines the impact of banking development on economic growth in Egypt between 1990 and 2023. It is organized as follows. Section 2 describes banking development and economic growth in Egypt over the past three decades. Section 3 presents an overview of the analytical literature on banking development and economic growth. Section 4 discusses econometric methodology and empirical results. Section 5 discusses and summarizes the

paper's main conclusions, including key policy implications to strengthen the positive impact of banking development on economic growth, and offers recommendations for future research.

2. Banking Development and Economic Growth in Egypt

2.1. Trends in Banking Development in Egypt

The Egyptian banking sector has witnessed various reform plans over the past three decades, beginning with the economic reform program, which included a financial liberalization policy as previously mentioned. These reforms contributed to the development of Egypt's banking sector during the 1990s.

The Egyptian government then developed specific banking reform programs between 2004 and 2011 to increase banking competition, encourage private investment, and reduce non-performing loans (NPLs). Key reforms included consolidation of the banking sector through merger and acquisition of small and weak banks; financial resolution of non-performing loans; privatization of one of the state-owned banks; financial and administrative restructuring of specialized state-owned banks and divesting public sector shares in joint venture banks (Reda, 2012).

As part of the continuous reforms in the banking sector, the Central Bank of Egypt has issued many regulations since 2012 in the framework of implementation of Basel II and Basel III for the pursuit of applying international best practices in banking supervision and risk management. Key regulations included raising the minimum threshold for the capital adequacy ratio; supporting the internal control applied by Egyptian banks; creating a capital conservation buffer to ensure adequate absorption of the potential losses; the management of interest rate risk in banking book

(IRRBB), and the management of concentration risk (CBE, 2023).

Figure 1 illustrates the performance of the three sub-indices of the Financial Institutions Index (FII): depth (FID), access (FIA), and efficiency (FIE). Among these, the FIE consistently records the highest values, indicating that financial institutions' efficiency has been the main driver of overall improvements in the FII. The linear trend estimation shows that the FII has increased at a stable annual rate of approximately 0.32%. This

upward trend is largely attributable to gains in efficiency, rather than to significant progress in depth or access. In practical terms, this suggests that the Egyptian banking sector has been more successful in optimizing the allocation and utilization of available financial resources than in expanding access to or the depth of financial services. Consequently, efficiency improvements appear to play a stronger role in fostering banking development and, by extension, in supporting economic growth.

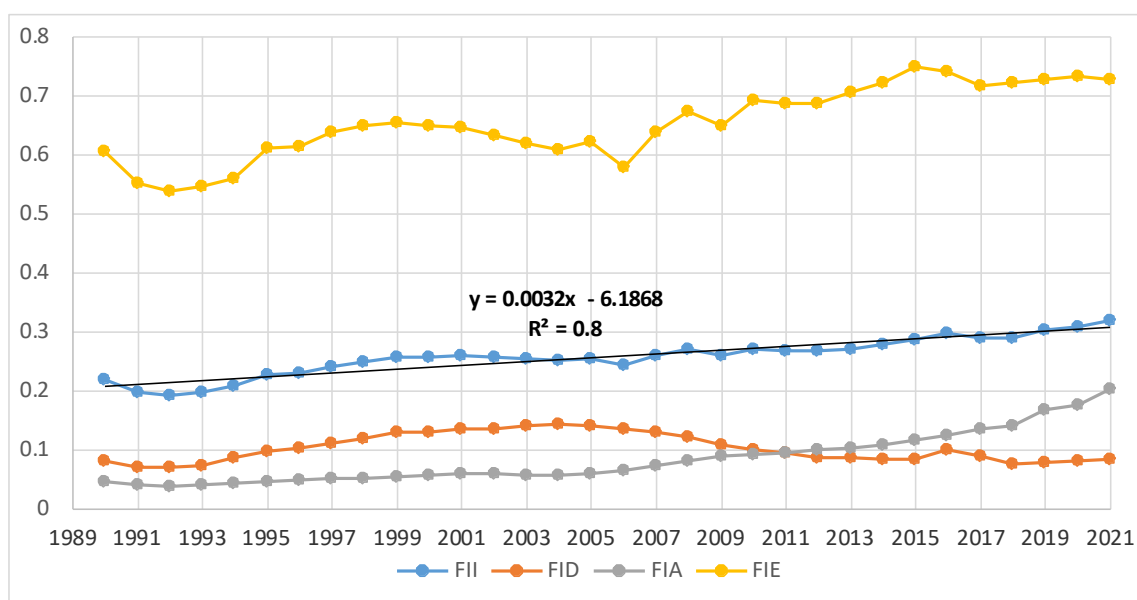


Figure (1): Financial institution index in Egypt, 1990-2021 (Source: IMF, 2023)

Notes: FII: Financial Institutions Index; FID: Financial Institutions Depth Index; FIA: Financial Institutions Access Index; FIE: Financial Institutions Efficiency Index

2.2. Trends in Economic Growth in Egypt

Egypt's economic growth has fluctuated significantly over the past three decades due to various challenges. We can analyze Egypt's economic growth by examining trends in the annual GDP per capita growth rate from 1990 to 2023.

We can see from Figure 2 that the annual growth rate of GDP per capita decreased from 3% in 1990 to -1.3% in 1991. Then, it gradually increased in the

1990s, reaching about 4.2% by the end of 2000. This could be due to the economic reform program that Egypt implemented in the 1990s, which included financial liberalization, privatization, and other policies that stimulated economic growth. The annual growth rate of GDP per capita decreased again in 2001 and 2002, likely due to internal and external shocks, most notably the September 11 attacks. However, economic performance improved once more, with the annual growth rate of GDP per capita reaching

about 5.1% in 2008. This improvement can be attributed to several factors, most importantly the successive reforms implemented by the Egyptian government during this period. These reforms included the rapid implementation of the privatization program to increase firms' efficiency and promote private investment, as well as continuous improvements in the business environment to attract more foreign direct investment (Ingham et al., 2020).

Figure 2 shows that the global financial crisis caused the annual growth rate of GDP per capita to decrease, reaching 2.6% by the end of 2009. Following the January 25 Revolution, economic growth turned negative.

However, Egypt's economic performance began to improve in 2014, with the annual growth rate of GDP per capita reaching about 2.1% by the end of 2015, likely due to higher contributions from the tourism, construction, and Suez Canal sectors (CBE, 2015). The annual growth rate of GDP per capita declined again after the outbreak of COVID-19, prompting Egyptian authorities to implement successive policy adjustments in response to ongoing shocks. As a result, economic performance improved during 2022. However, it was negatively affected by global shocks in 2023, leading to a decrease in the annual growth rate of GDP per capita to reach 2.2% (Gatti et al., 2024).

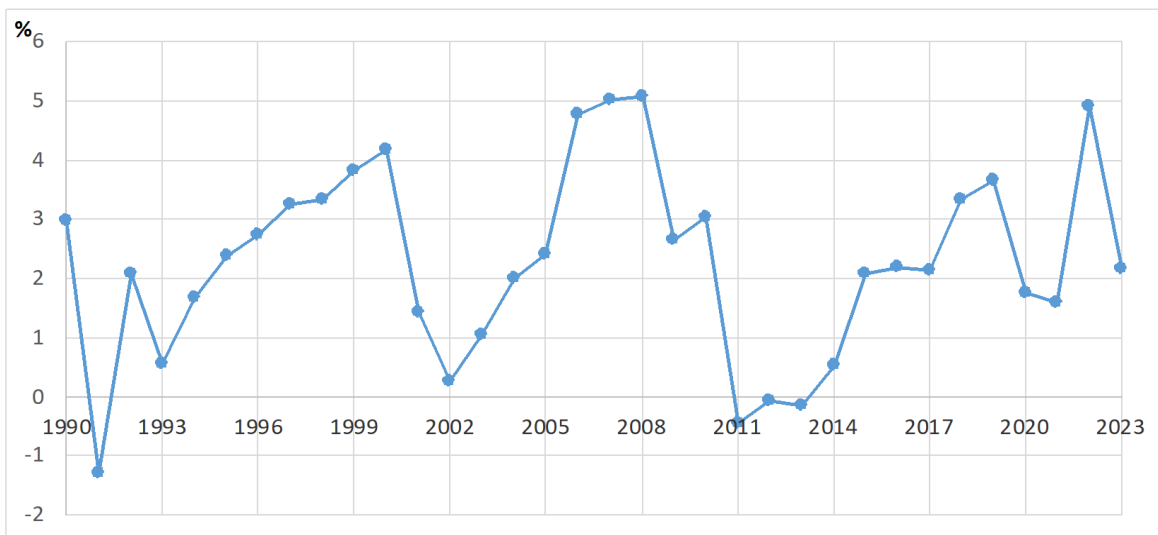


Figure (2): Annual growth rate of GDP per capita in Egypt, 1990-2023 (Source: World Bank, 2024)

3. Theoretical Foundations and Empirical Literature

The theoretical economic literature offers a wide range of perspectives and insights on banking development and economic growth. Walter Bagehot was the first to show the role of banks in the real economy; he argued that financial intermediation plays a critical role in boosting industrialization in England and that by facilitating the mobilization of capital for productive investment (Mhadhbi et al., 2020).

Keynes did not explicitly discuss banking development, but he advocated for financial repression and government intervention in banking services through interest rate ceilings, liquidity ratio requirements, high bank reserve requirements, capital controls, restrictions on market entry into the banking sector, credit ceilings or limitations on the directions of credit allocation, and government ownership or domination of banks (Alimi & Adeoye, 2020). Therefore, we conclude that he opposed

banking development based on financial liberalization.

An explicit theoretical link between banking development and economic growth can be traced back to Schumpeter, who emphasized the importance of banking development in promoting economic growth as he called for non-governmental intervention in the economy and argued that the banking sector is a leader in research, technological innovation, savings pooling, risk diversification and allocating financial resources efficiently towards highly productive projects in the economy (Tsaurai, 2023).

According to the McKinnon–Shaw hypothesis, banking development based on financial liberalization will amplify competition, increase savings by raising interest rates, and thereby promote investment, ultimately promoting economic growth. Hence, they advocated for Schumpeter’s thoughts (Guru & Yadav, 2019). On the other hand, neo-Keynesians argued for direct state intervention in the banking sector to correct market failures arising from information asymmetry. They supported Keynes’ views on state intervention in a regulated banking sector, which McKinnon and Shaw termed “financial repression” (Johannes et al., 2011).

A substantial body of literature examines the impact of banking development on economic growth, revealing a complex and often contradictory landscape. While theoretical economics and empirical studies alike present varying conclusions, a predominant number of investigations—including those by Reddy et al. (2023), Nwagu et al. (2023), Rossi & Scalise (2022), Nguyen (2022), Samour et al. (2022), Shahbaz et al. (2022), Almahadin et al. (2021), Mekango (2021), and Ibrahim & Abdalla (2020)—affirm a

notably positive correlation between banking development and economic growth. These studies employ diverse datasets and econometric techniques, underscoring the validity of their findings.

Furthermore, research by Sarwar et al. (2021), Abdulrahman et al. (2020), and Sethi et al. (2020) suggests that financial development has a significant and beneficial effect on economic growth in emerging economies. In contrast, a minority of economists, including Tongurai & Vithessonthi (2018) and Sonmez & Saglam (2017), highlight instances where banking sector development may have a detrimental impact on economic growth.

Additional studies by Mtar & Belazreg (2023), Wen et al. (2022), and Cheng et al. (2021) assert that financial development tends to be unfavorable for economic growth, with this negative impact being markedly pronounced in high-income nations. Cave et al. (2020) also contribute to this discourse by identifying a robust negative relationship between banking sector development and economic growth. Conversely, Narayan & Narayan (2013), in their examination of 65 developing countries from 1995 to 2011, conclude that bank credit adversely affects economic growth.

Other scholars, such as Herwartz & Walle (2014), argue that there exists no statistically significant impact of banking sector development on economic growth. This prevailing ambiguity in the literature underscores the need for further inquiry into the nuanced relationship between banking development and economic vitality, suggesting that context-specific factors may play a critical role in determining its nature.

Gaps in Literature: An Academic Perspective

Previous empirical studies have predominantly employed one or two measures to approximate banking development, specifically the ratio of private credit to GDP and/or broad money to GDP. However, these singular indicators fail to adequately capture the complex, multidimensional nature of banking development, as reliance on single proxies is insufficient to portray its true capacity. The present paper aims to contribute to this discourse by assessing the impact of banking development on economic growth through the utilization of a comprehensive index, specifically the Financial Institution Index (FII), as developed by the International Monetary Fund (IMF).

This index is disaggregated into three distinct sub-indices: the Financial Institutions Efficiency (FIE) Index, the Financial Institutions Depth (FID) Index, and the Financial Institutions Access (FIA) Index. Each of these sub-indices is carefully constructed using a robust array of indicators designed to measure the depth, accessibility, and efficiency of banking institutions (Svirydzenka, 2016). This study focuses on to inform the reformulation of strategies to bolster the country's low and unstable economic growth.

Egypt presents an exemplary case study for analyzing the interplay between banking development and economic growth, particularly in light of its unique contextual factors. The nation embraced trade openness in 1974 and embarked on a path of financial liberalization during the 1990s. Furthermore, the Central Bank of Egypt functions as the primary regulatory authority, issuing directives to the banking sector and overseeing their stringent implementation. Thus, all necessary conditions for fostering banking

development, as delineated by theories surrounding interest groups, financial liberalization, and the interplay of law and finance, are fundamentally met (Aluko & Ajayi, 2018; Porta et al., 1998; Rajan & Zingales, 2001).

This paper seeks not only to fill existing gaps in the literature but also to provide a robust framework for understanding the implications of banking development for economic growth, particularly in the Egyptian context.

4. Econometric Methodology and Modeling Strategy

4.1. Model Specification

The econometric model is based on the Cobb-Douglas production function, which represents the relationship between the quantities of the factors of production -capital and labor- and the quantity of output produced by these factors (Tsounis & Vlachvei, 2018). This paper augments the Cobb-Douglas production function to include banking development and several control variables that affect economic growth in Egypt, as reported in the empirical studies (as shown in Eq. 1).

$$GDPP = f(FII, L, K, TO, INF) \dots \dots \dots (1)$$

The econometric model (Eq. 2) represents the Cobb-Douglas production function in a double-log functional form as follows:

$$\ln GDPP_t = \alpha + \beta_1 \ln FII_t + \beta_2 \ln L_t + \beta_3 \ln K_t + \beta_4 \ln TO_t + \beta_5 \ln INF_t + u_t \dots (2)$$

Were,

- GDPP: GDP per capita (constant 2015 US\$). It is used to measure economic growth, and it represents the dependent variable in the model.
- FII: Financial Institution Index. It is used to measure banking

development and serves as the explanatory variable in the model. It is expected to have a positive effect on economic growth.

- L: Employment to population ratio. It is used as a proxy for labor. It to positively affect economic growth.

- K: Gross capital formation as a percentage of GDP. It is used as a proxy for capital. It to positively affect economic growth.

- TO: Trade openness as measured by the sum of exports and imports of goods and services as a percentage of GDP. It serves as a control variable in the model and is expected, based on theoretical and empirical evidence from Egypt, to positively affect economic growth (Youssef, 2023).

- INF: Inflation as measured by the annual growth rate of the GDP

deflator. It serves as a control variable in the model and is expected, based on theoretical and empirical evidence from Egypt, to negatively affect economic growth (Sallam, 2016).

All data obtained from the World Development Indicators (WDI) published by the World Bank in 2024, except for the financial institutions index, which was developed by the International Monetary Fund. However, the data for the last two years of the financial institution index were generated by the authors using the trend-line equation, after confirming that the variable remained stable over time.

4.2. Unit Root Tests

The primary step variables. Thus, we use the Augmented Dickey-Fuller and Phillips-Perron tests as shown in Table 1.

Table (1): Unit Root Tests

Panel A: Augmented Dickey-Fuller					
Variable	Variable at the Level		Difference Variable in the First		()Integration Order I
	Constant	Constant & Trend	Constant	Constant & Trend	
	t-Statistic Prob.*	t-Statistic Prob.*	t-Statistic Prob.*	t-Statistic Prob.*	
ln GDPP	-0.70899 (-0.8304)	-2.88466 (-0.1804)	-3.65481 (-0.01)	-3.52149 (-0.0539)	1
ln FII	-0.6232 (-0.852)	-2.3566 (-0.394)	-5.92626 (0.0000)	-5.87002 (-0.0002)	1
ln L	-2.41861 (-0.1446)	-2.27954 (-0.4328)	-5.77496 (0.0000)	-5.63558 (-0.0003)	1
ln K	-2.73503 (-0.079)	-3.61909 (-0.045)	-4.6462 (-0.0008)	-4.41871 (-0.0071)	0
ln TO	-2.57476 (-0.1085)	-2.64731 (-0.2636)	-4.44193 (-0.0013)	-4.37186 (-0.0079)	1
ln INF	-2.76608 (-0.0742)	-3.01066 (-0.1446)	-6.42402 (0.0000)	-6.4476 (0.0000)	1
Panel B: Phillips-Perron					
Variable	Variable in Level		Variable in First Difference		()Integration Order I
	Constant	Constant & Trend	Constant	Constant & Trend	

	t-Statistic Prob.*	t-Statistic Prob.*	t-Statistic Prob.*	t-Statistic Prob.*	
ln GDPP	0.21448 (-0.9695)	-2.45164 (-0.3483)	-3.65481 (-0.01)	-3.52149 (-0.0539)	1
ln FII	-0.67462 (-0.8395)	-2.66565 (-0.25620)	-6.00352 (0.0000)	-5.87002 (-0.0002)	1
ln L	-2.56363 (-0.1105)	-2.54596 (-0.3057)	-5.74044 (0.0000)	-5.61367 (-0.0003)	1
ln K	-2.79875 (-0.0695)	-3.39354 (-0.0695)	-4.60978 (-0.0008)	-4.27119 (-0.01)	1
ln TO	-1.88603 (-0.3345)	-2.19603 (-0.4761)	-4.35343 (-0.0017)	-4.26289 (-0.0103)	1
ln INF	-2.77092 (-0.0734)	-2.99677 (-0.1482)	-6.92849 (0.0000)	-7.1935 (0.0000)	1

Source: authors' estimation

Table (1) shows that, according to the ADF and PP tests, all variables are either integrated of order zero, I (0), or integrated of order, I (1). Since there is no variable that has an integration order

higher than one, we can employ ARDL model. The ARDL model approach to Cointegration testing is shown as follows (Eq. 3):

$$\begin{aligned} \Delta \ln GDPP_t = & \alpha + \gamma \ln GDPP_{t-1} + \delta_1 \ln FII_{t-1} + \delta_2 \ln L_{t-1} + \delta_3 \ln K_{t-1} \\ & + \delta_4 \ln TO_{t-1} + \delta_5 \ln INF_{t-1} + \sum_{i=1}^{\rho-1} \lambda_{1i} \Delta \ln GDPP_{t-i} \\ & + \sum_{i=0}^{q-1} \lambda_{2i} \Delta \ln FII_{t-i} + \sum_{i=0}^{s-1} \lambda_{3i} \Delta \ln L_{t-i} + \sum_{i=0}^{n-1} \lambda_{4i} \Delta \ln K_{t-i} \\ & + \sum_{i=0}^{m-1} \lambda_{5i} \Delta \ln TO_{t-i} + \sum_{i=0}^{v-1} \lambda_{6i} \Delta \ln INF_{t-i} + u_t \dots (3) \end{aligned}$$

In Eq. 3, Δ refers to first differences. α refers to the intercept. ρ q s n m v Refer to the maximum lag order. λ_i represents the short-run coefficient for each variable. δ_1 δ_2 δ_3 δ_4 δ_5 represent long-run multipliers used to get long-run relationships of the underlying variables.

4.3. Cointegration Test

A cointegration test is used to determine whether two or more non-stationary time series are cointegrated, meaning they do not deviate from equilibrium in the long run (Gujarati &

Porter, 2009). Thus, cointegration establishes a stronger statistical and economic basis for the empirical error correction model, which brings together short and long-run information in modeling economic time series that converges over time. Testing for cointegration is a necessary step to establish if a model empirically exhibits meaningful long-run relationships. If it failed to establish cointegration among the underlying variables, it becomes imperative to continue working with the variables in differences instead. However, the long-run information will be missing (Nkoro & Uko, 2016).

Table (2) shows that the computed F-statistic is greater than the upper bound critical value at 1% significance level, so we can reject the null hypothesis of no

level relationship, indicating that the variables are cointegrated and there are meaningful long-run relationships between them.

Table (2): Bounds test

F-Bounds Test		Null Hypothesis: No levels relationship		
Test Statistic:	Value:	Signif.	Lower Bound Value I(0)	Upper Bound Value I(1)
F-statistic	17.34685	10%	2.75	3.79
		5%	3.12	4.25
		2.50%	3.49	4.67
		1%	3.93	5.23

Source: authors' estimation

4.4. Estimation, Empirical Results, and Interpretation of the long-run parameters.

Once we established that a long-run cointegration relationship existed, we can estimate the long-run relationships using the following ARDL specification (Eq. 4):

$$\ln GDP_t = \alpha + \sum_{i=1}^p \gamma_i \ln GDP_{t-i} + \sum_{i=0}^q \delta_{1i} \ln FII_{t-i} + \sum_{i=0}^s \delta_{2i} \ln L_{t-i} + \sum_{i=0}^n \delta_{3i} \ln K_{t-i} + \sum_{i=0}^m \delta_{4i} \ln TO_{t-i} + \sum_{i=0}^v \delta_{5i} \ln INF_{t-i} + u_t \dots \dots (4)$$

In equation 4, $p q s n m v$ Refer to the maximum lags, which were determined by the authors to be one lag for the dependent variable and three lags for the explanatory and control variables, based on the best results obtained (as

shown in Table 3). The long run parameters are obtained by using the following formula: $\beta = \frac{\sum_{i=0}^q \delta_i}{1 - \sum_{i=1}^p \gamma_i}$

Table (3): ARDL Long Run Form

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNFI	0.297541	0.048471	6.138554	0.0003*
LNL	0.499135	0.038187	13.07068	0.0000*
LNK	0.138685	0.011982	11.57484	0.0000*
LNTO	0.06696	0.009155	7.314034	0.0001*
LNINF	-0.014806	0.003464	-4.27357	0.0027*
R²			0.999955	

Variable	Coefficient	Std. Error	t-Statistic	Prob.
	Adj. R^2		0.999832	
	F-Statistic		8101.346	
	(P-Value)		0)0(0.00	

* 1% significance level

Source: authors' estimation

Based on the results obtained from Table 3, we can formulate the regression equation (Eq. 5) in its final form as follows:

$$\ln GDP_t = 0.2975 \ln FII_t + 0.4991 \ln L_t + 0.1387 \ln K_t + 0.0670 \ln TO_t + 0.0148 \ln INF_t + u_t \dots \dots \dots (5)$$

From Table (3), we can see that all estimated coefficients are theoretically significant as their signs are consistent with economic theory and they are also statistically significant at 1% significance level, so we can conclude that:

- There's a statistically significant positive relationship between banking development and economic growth in Egypt; when banking development changes by 1%, GDP per capita tends to change by 0.3% in the same direction, ceteris paribus.

- There's a statistically significant positive relationship between labor and economic growth in Egypt; when labor changes by 1%, GDP per capita tends to change by 0.5% in the same direction, ceteris paribus.

- There's a statistically significant positive relationship between capital and economic growth in Egypt; when capital changes by 1%, GDP per capita tends to change by 0.14% in the same direction, ceteris paribus.

- There's a statistically significant positive relationship between trade openness and economic growth in Egypt; when trade openness changes by 1%, GDP per capita tends to change by 0.07% in the same direction, ceteris paribus.

- There's a statistically significant negative relationship between inflation and economic growth in Egypt; when inflation changes by 1%, GDP per capita tends to change by 0.015% in the opposite direction, ceteris paribus.

4.5. Estimation, Empirical Results, and Interpretation of the Short Run Parameters

According to the Error Correction Model (ECM), the short-run regression equation is specified as follows (Eq. 6):

$$\Delta \ln GDP_t = \alpha + \sum_{i=1}^{\rho-1} \lambda_{1i} \Delta \ln GDP_{t-i} + \sum_{i=0}^{q-1} \lambda_{2i} \Delta \ln FII_{t-i} + \sum_{i=0}^{s-1} \lambda_{3i} \Delta \ln L_{t-i} + \sum_{i=0}^{n-1} \lambda_{4i} \Delta \ln K_{t-i} + \sum_{i=0}^{m-1} \lambda_{5i} \Delta \ln TO_{t-i} + \sum_{i=0}^{v-1} \lambda_{6i} \Delta \ln INF_{t-i} + \omega ECT_{t-1} + u_t \dots \dots \dots (6)$$

The short-run empirical results are represented in Table 4. From Table 4, the short-run estimated coefficients can be interpreted as follows:

- There's a statistically significant positive relationship between banking development and economic growth in Egypt in the short run. However, this relationship turns negative after one or two lagged periods. This can be explained by the fact that increased credit to the private sector through financial liberalization and privatization encourages companies to invest in new productive projects, leading to higher economic growth. However, after one or two years,

companies may realize that they have over-expanded, with their production capacity exceeding the demand for goods and services. This could reduce profits, as companies are forced to sell excess production, prompting them to scale back future investments, which in turn slows economic growth. Thus, this period can be seen as a phase of "economic adjustment". Despite the potential for a temporary negative impact on economic growth during this phase, it is considered a necessary stage in which the economy's absorptive capacity is assessed, allowing the Egyptian economy to fully benefit from the positive effects of banking development.

Table (4): ARDL Error Correction Regression

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	5.460725	0.418097	13.06092	0.0000*
D(LNFII)	0.071349	0.018096	3.942842	0.0043*
D(LNFII(-1))	-0.077884	0.02244	-3.470756	0.0084*
D(LNFII(-2))	-0.083995	0.021518	-3.903536	0.0045*
D(LNL)	0.281308	0.022103	12.7271	0.0000*
D(LNL(-1))	-0.127168	0.035028	-3.630449	0.0067*
D(LNL(-2))	-0.066785	0.02194	-3.043998	0.016**
D(LNK)	0.059097	0.004994	11.83289	0.0000*
D(LNK(-1))	-0.045967	0.008145	-5.643504	0.0005*
D(LNK(-2))	-0.047222	0.008287	-5.698203	0.0005*
D(LNTO)	-0.023841	0.006551	-3.639123	0.0066*
D(LNTO(-1))	-0.025889	0.007277	-3.557431	0.0074*
D(LNTO(-2))	0.015585	0.005674	2.746825	0.0252**
D(LNINF)	0.00646	0.001169	5.525161	0.0006*
D(LNINF(-1))	0.014102	0.001658	8.507714	0.0000*
D(LNINF(-2))	0.00174	0.001115	1.560517	0.1573
CointEq(-1)*	-0.994744	0.076489	-13.00507	0.0000*
R²			0.991254	
Adj. R²			0.979817	
F-Statistic			86.67033	
(P-Value)			(0.0000)	

*, ** 1%, 5% significance level, respectively

Source: authors' estimation

- There's a statistically significant positive relationship between labor and economic growth in Egypt in the short run. However, this relationship turns negative after one or two lagged periods, likely due to the law of diminishing returns.

- There's a statistically significant positive relationship between capital and economic growth in Egypt in the short run. However, this relationship turns negative after one or two lagged periods, likely due to the law of diminishing returns.

- There's a statistically significant negative relationship between trade openness and economic growth in Egypt in the short run and after a one-period lag. However, this relationship turns positive after two lagged periods. This may be attributed to the fact that developing countries need time to study foreign markets to compete with their counterparts from foreign countries. Trade openness requires reallocating resources from less competitive sectors to more competitive ones. However, this reallocation process can incur high short-run costs, in addition to the need for retraining labor and investing in new, innovative, productive projects. These factors may lead to a temporary slowdown in economic growth.

- There's a statistically significant positive relationship between inflation and economic growth in Egypt in the short run and after a one-period lag. This can be

explained by the fact that inflation may increase consumer spending in the short run. When people expect prices to rise in the future, they may prefer to purchase goods and services now before prices increase further, leading to higher aggregate demand and economic growth. Additionally, companies may increase in higher prices. As a result, economic growth may temporarily accelerate.

- The estimated coefficient of the error correction term, or the speed of adjustment, (ω) is negative and statistically significant, indicating that the underlying variables will converge back to the long-run equilibrium. Additionally, its value implies that 99.47% of the short-run disequilibrium will be corrected annually, meaning that the equilibrium will be restored within the same period.

- The intercept coefficient ($e^{5.460725} = 235.2679$) indicates that the real GDP per capita is about \$235 when the explanatory and control variables = zero. It refers to the Total Factor Productivity (TFP).

4.6. Regression Diagnostics

The aim of regression diagnostics is to evaluate the validity and reliability of a regression model, ensuring that it provides unbiased and efficient estimates of the underlying variables. The results are shown in Table 5.

Table (5): Results of Diagnostic Tests

Test	Calculated Statistic	P-value
Breusch-Godfrey Serial Correlation LM Test	F-statistic = 3.347197	0.1344
Breusch-Pagan-Godfrey Heteroscedasticity Test	Chi-square = 25.19004	0.2881
White Heteroscedasticity Test	26.38269 Chi-square =	0.2356

Test	Calculated Statistic	P-value
Normality Test	Jarque-Bera = 1.216371	0.544338
Ramsey RESET Test	0.351531F-statistic =	0.5719

Source: authors' estimation

From the results in Table 5, we cannot reject the null hypotheses of no serial autocorrelation at up to 4 lags, homoscedasticity, normally distributed residuals, and no omitted variables or misspecification, indicating that the estimated coefficients are unbiased and

efficient. From Figure 3, we can see that the CUSUM and CUSUMSQ plots remain within the critical bounds, suggesting that there is no evidence of structural instability in the model. This indicates that the parameters are stable over the sample period.

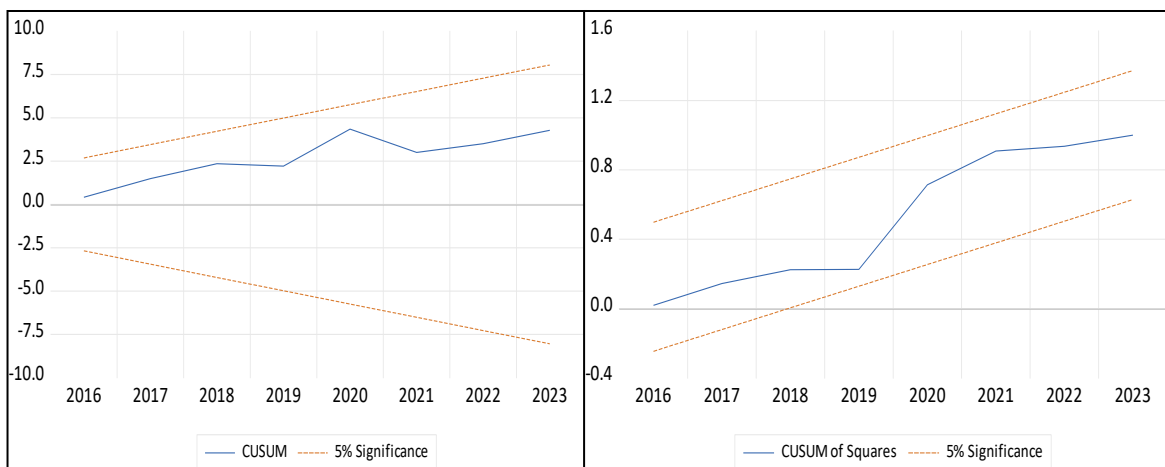


Figure (3): Results of the structural stability tests (Source: authors' estimation)

5. Discussion & Conclusion

This study critically examines the relationship between banking development and economic growth in Egypt, drawing from theoretical frameworks and empirical evidence. The

findings indicate a lack of consensus on the impact of banking sector development on economic growth. Our analysis utilizes a comprehensive dataset of financial institution indices introduced by the IMF, focusing on the period from 1990 to 2023. Employing the Autoregressive Distributed Lag (ARDL) model, the research reveals robust evidence of a statistically significant positive effect of banking development, trade openness, labor, and

capital on economic growth in Egypt. Conversely, the study identifies a statistically significant negative impact of inflation on economic growth.

The empirical findings are broadly consistent with a growing body of literature that highlights the growth-enhancing role of banking sector development. For instance, Tsaouri (2023) demonstrates a positive and significant effect of banking development on economic growth across BRICS countries, emphasizing the need for Complementary policies to strengthen domestic investment. Similarly, Hammami & Smida (2022) provide evidence from Tunisia that banking-based financial development fosters growth, reinforcing the argument that bank-

oriented systems can play a crucial role in emerging economies. In Ukraine, Rushchyshyn et al. (2021) reveal a strong favorable relationship between banking sector development and GDP per capita, underscoring the sector's potential in driving socio-economic progress, despite lagging behind EU benchmarks. By contrast, our results diverge from Tongurai & Vithessonthi (2018), who identify adverse effects of banking development on agricultural growth in highly developed banking systems.

Specifically, this study finds that a 10% increase in banking development corresponds to a 3% increase in economic growth—an intermediate to strong effect, particularly considering that Egypt's banking sector remains nascent, with an average index value of 0.3 during the study period (on a scale from 0 to 1). This underscores the substantial potential for Egypt to leverage banking development of economic growth. It is imperative that policymakers commit to ongoing enhancements within the banking sector to amplify these positive impacts.

To this end, we propose a series of policy implications aimed at maximizing the beneficial effects of banking development on economic growth in Egypt. These recommendations include advocating for a more proactive engagement with the private sector and facilitating the entry of foreign banks into the Egyptian market. Additionally, the focus should be on the continuous implementation of the best international practices in banking supervision and risk management. This may involve regulations from the Central Bank of Egypt, such as establishing an additional buffer for the leverage ratio and enhancing the existing leverage ratio for domestic systemically important banks (D-SIBs). Moreover, instituting an output floor, which represents a specific percentage of capital requirements based

on the standardized approach for banks utilizing internal models for risk assessment, could bolster sector stability.

Activating the provisions outlined in Chapter Six of the Egyptian Banking Law No. 194 of 2020, concerning , given insufficient transparency in banking services, will be pivotal. The Central Bank's proactive involvement in reviewing and resolving such disputes can foster greater customer confidence and of their rights.

Furthermore, comprehensive advertising campaigns initiated by banks could significantly enhance public awareness of banking services, facilitating a better understanding of their utility. These campaigns should include successful testimonials from individuals or enterprises that have derived tangible benefits from banking services, thereby inspiring wider engagement with banking activities across society.

To enhance human capital within the sector, banks are encouraged to organize regular training sessions for employees on essential topics such as risk management, financial analysis, financial technology, and banking regulations. Collaborating with specialized training institutions may optimize these sessions. Additionally, incentivizing employees to pursue internationally recognized professional certifications can lead to improved operational efficiency and performance, ensuring that gains from banking development translate effectively into economic growth.

Lastly, it is critical that the Egyptian government implement measures to harness the benefits of trade openness, focusing on bolstering the competitiveness of Egyptian exports, alongside policies to control inflation to create a conducive investment climate. These initiatives are fundamental to

reinforcing the positive relationship between banking development and economic growth in Egypt.

In conclusion, this study advocates for future research that extends the investigation into the nexus between banking development and economic growth in Egypt, specifically examining the influences of financial technology and interest rate policies. Additionally, exploring the impact of stock market development or broader financial development on economic growth would provide valuable insights into the multifaceted dimensions of financial development in the Egyptian context.

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DOI: 10.33948/ESJ-KSU-18-1-5

تأثير التطور المصرفي على النمو الاقتصادي: دراسة تطبيقية على مصر خلال الفترة 1990-2023

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(قُدِّم للنشر: 10 يوليو، 2025م - وقُبِل للنشر: 07 سبتمبر، 2025م)

المستخلص: تهدف الدراسة إلى فحص تأثير تطور الجهاز المصرفي على النمو الاقتصادي في مصر خلال الفترة (1990-2023) في الأجلين الطويل والقصير، وذلك من خلال تعيين نموذج الانحدار الذاتي ذي الفجوات الموزعة ARDL لتقدير علاقات الأجل الطويل، فضلاً عن استخدام نموذج تصحيح الخطأ ECM لقياس علاقات الأجل القصير، وتوصلت نتائج الدراسة إلى أن التطور المصرفي يؤثر إيجابياً ومعنوياً على النمو الاقتصادي في الأجل الطويل، وجاءت نتائج الأجل القصير متوافقة بشكل كبير مع نتائج الأجل الطويل، وتؤكد هذه النتائج على ضرورة وضع مجموعة من السياسات الهادفة إلى تعظيم أثر التطور المصرفي على النمو الاقتصادي في مصر. وتشمل التوصيات تعزيز مشاركة القطاع الخاص، وتشجيع دخول البنوك الأجنبية، وتبني أفضل الممارسات الدولية في الإشراف وإدارة المخاطر، إلى جانب تفعيل أحكام قانون البنوك بشأن حماية حقوق العملاء وزيادة الوعي العام بالخدمات المصرفية. كما تؤكد على تنمية رأس المال البشري عبر التدريب والشهادات المهنية، مع تبني سياسات اقتصادية داعمة مثل تعزيز الانفتاح التجاري، وزيادة تنافسية الصادرات، والسيطرة على التضخم، بما يعزز التأثير الإيجابي للتطور المصرفي على النمو الاقتصادي.

الكلمات المفتاحية: تطور الجهاز المصرفي؛ النمو الاقتصادي؛ نموذج ARDL؛ نموذج تصحيح الخطأ ECM؛ الاقتصاد المصري.

Assessing the Impact of Economic Shocks on the Exchange Rate of the Egyptian Pound During the period 1977-2022

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(Received: March 03, 2025; accepted for publication: July 02, 2025)

Abstract: *This study analyzes how economic shocks affect Egypt's exchange rate (1977–2022), focusing on external debt, reserves, and inflation. Using VAR models and World Bank data, the findings reveal That Exchange rate shocks and their determinants (reserves, inflation, debt) exhibit prolonged impacts that fade slowly. The exchange rate is most vulnerable to its own shocks, followed by reserves (the strongest external influence), domestic inflation, imported inflation, and external debt. Domestic inflation shocks are more damaging and persistent than imported ones. Recommendations include adopting dependence, and bolstering foreign reserves to enhance resilience to external shocks. The study underscores the need for structural reforms to stabilize Egypt's exchange rate amid economic turbulence.*

Keywords: *Exchange rate, Egyptian pound, Economic shocks, Domestic inflation, Imported inflation, External debt, Foreign reserves.*

1. Introduction:

Shocks to the exchange rate can be economic, political, or social and can significantly affect currency stability, including that of the Egyptian pound, whether positive (desirable) or negative (undesirable). Shocks are reflected in the form of fluctuations, such as political fluctuations, such as changes in government or fluctuations in economic policies, that can cause instability and affect confidence in the currency. Economic fluctuations such as a decline in economic growth or an increase in unemployment rates can lead to a weak currency, and global events such as the occurrence of global financial crises or geopolitical tensions can affect investor confidence and push the currency to

fluctuation, and fluctuations in commodity markets such as an increase or decrease in the prices of basic commodities that the country depends on, which can affect the exchange rate. And changes in interest rates: An increase or decrease in interest rates affects investment and external financial flows and thus the exchange rate.

Currencies are greatly affected by such factors, but the reaction of the Egyptian pound exchange rate may differ depending on the policies of the Central Bank and the Egyptian economy in general. fluctuations. The government or the central bank may intervene in the market to stabilize the exchange rate or reduce its volatility.

1-1. Research problem

Different types of shocks affect the Egyptian pound exchange rate, especially economic shocks, either directly or indirectly by influencing the determinants of the exchange rate, which raises the question: "What is the impact of economic shocks on the stability of the Egyptian pound exchange rate?"

What are the most important determinants of the exchange rate of the Egyptian pound? What is the impact of economic shocks on the most important determinants of the exchange rate of the Egyptian pound?

1-2. Importance of the research:

The importance of the research comes from:

The importance of the Egyptian pound exchange rate and its impact on various economic variables.

Understanding the nature of the shocks that affect the Egyptian pound exchange rate and how to confront them.

The importance of applied economics for the economic theory of the exchange rate. This is consistent with what economists such as Milton Friedman argue: the theoretical (hypothetical) aspect, if it cannot be proven by reference to applied evidence, does not rise to the level of scientific research. (Milton Friedman, 1953).

The results and recommendations develop monetary and financial policies that achieve exchange rate stability, thereby reducing the risks associated with exchange rate fluctuations.

1-3. Study objectives:

The study aims to:

- To identify the direct and indirect impact of economic shocks on the Egyptian pound exchange rate."

- Determine the most important determinants of the exchange rate of the Egyptian pound

- Analysis of the impact of economic shocks on the main determinants of the exchange rate of the Egyptian pound, and understanding how these factors interact with different shocks.

1-4. Study hypotheses:

The research examines the validity of the following hypotheses:

The most important determinants of the exchange rate of the Egyptian pound are the total balance of external debt (due and disbursed debt, at current prices of the US dollar), total reserves (including gold, at current prices of the US dollar), inflation, the GDP deflator (% per annum), and inflation, the GDP deflator (% per annum) - for the United States of America

The impact of shocks on the exchange rate of the Egyptian pound and its determinants is long-term (slowly fading).

Difficulty in treating external shocks on the Egyptian pound exchange rate

1-5. Research methods

The research employs an analytical approach to assess the impact of shocks on the Egyptian pound exchange rate, using econometric tools to analyze the exchange rate's response and its determinants to shocks via the VAR model, implemented in EViews 12.

Data sources: A desk study is conducted for a group of research and studies on shocks and their effects on the exchange rate of the Egyptian pound at the level of theoretical economics, applied economics and econometrics, and based on the World Bank's statistics on the exchange rate and its determinants during the period (1977-2022) due to the availability of a complete series in the World Bank data.
Study limits: Spatial scope: The Arab Republic of Egypt. Temporal scope: The

period (1977–2022), given the availability of a complete dataset from the World Bank."

1-6. Study contents:

This research consists of Exchange rate basics and shock basics. The impact of shocks on the exchange rate of the Egyptian pound, *Econometrics Study*.

2. Previous studies:

Ismail & Galal (2024): The study examines the impact of exchange rate fluctuations on the velocity of money in Egypt (2000–2024). Using ARIMA models, it finds significant relationships between money velocity and variables such as foreign reserves, money supply, real interest rate, GDP, and per capita income. Results show that exchange rate changes negatively affect money velocity. The study highlights the role of these variables in shaping monetary policy.

Comment: The study provides a comprehensive analysis of how exchange rate fluctuations affect the velocity of money in Egypt, incorporating several relevant macroeconomic variables. It effectively links monetary theory with real-world data using ARIMA modeling.

Research Gap: While the study covers multiple determinants, it lacks a deeper exploration of structural factors (such as institutional quality or digital financial inclusion) that may also influence money velocity. It also does not address causality beyond correlations.

Alabdulwahab (2024): This study explores the sources of real exchange rate fluctuations in Egypt (1980–2016) using an SVAR model. It finds that demand shocks have the strongest and most lasting impact, while monetary shocks are short-lived and minor. Recommendations include addressing demand distortions and improving the effectiveness of monetary policy. The study emphasizes domestic

investment to reduce foreign currency pressure.

Comment: This study makes a strong contribution by distinguishing between different types of shocks (demand, supply, monetary) and assessing their impact on exchange rate behavior using advanced econometric techniques (SVAR, IRF, VDC).

Research Gap: It does not explore how external shocks (e.g., global oil prices, geopolitical risks) interact with domestic shocks. Additionally, more recent data post-2016 would enhance relevance given recent economic reforms.

Mansour & Hassan (2021): Focused on Egypt (2002–2019), this study investigates long-term determinants of the real exchange rate using Johansen cointegration and VAR models. It finds that government spending, international reserves, and remittances positively impact the exchange rate. However, trade openness and terms of trade showed no significant long-term effects. Growth rate had a mixed influence depending on other variables.

Comment: The study offers valuable insights into the long-term drivers of Egypt's real exchange rate, using robust econometric methods. It finds significant effects of government spending and remittances.

Research Gap: It lacks analysis of structural reforms, financial sector development, and global value chain integration. The exclusion of the post-2019 period limits its applicability to recent currency dynamics.

Guizani (2019): This study analyzes the effect of real exchange rate shocks on trade in three oil-importing MENA countries (2000–2017). Using VAR models, it finds exchange rate policies had weak influence on trade, especially post-Arab Spring. Non-price factors like

product quality and competitiveness had a larger role. It recommends reducing reliance on currency depreciation and diversifying markets.

Comment: This research critically examines the limited role of exchange rate adjustments in enhancing trade, especially in uncertain times. It provides evidence from a regional perspective.

Research Gap: The study does not investigate micro-level trade data (sector-specific or firm-level). It also assumes uniform effects across countries without deeply analyzing cross-country structural differences.

Elsherif (2016): The study examines exchange rate volatility in Egypt after the 2003 float, using the GARCH (1,1) model (2003–2014). It assesses how central bank measures—interest rate differentials and reserves—affect volatility. Findings show volatility clustering, with interest rates increasing volatility and reserves reducing it. Central bank interventions have mixed effects on currency stability.

Comment: A well-executed application of the GARCH model to assess exchange rate volatility and policy impact, offering practical insights into the role of the Central Bank.

Research Gap: It does not examine the impact of capital flows, speculative activities, or external shocks. The study also ends in 2014, missing Egypt's major monetary reforms post-2016.

Hosni & Rofael (2015): This research evaluates Egypt's real exchange rate misalignments (1999–2012) using PPP, FEER, and Edwards models. Results indicate the pound was undervalued (2003–2007) and overvalued (2001–2002, 2008–2012). Misalignments harm competitiveness and economic performance. The study calls for maintaining equilibrium to support exports and avoid persistent misevaluation.

Comment: The study effectively uses several models to assess exchange rate misalignments in Egypt and links misalignment to macroeconomic performance.

Research Gap: The work could be enhanced by incorporating dynamic panel data, and by evaluating the impact of misalignments on specific sectors like manufacturing or tourism.

Gadou (2015): The study investigates the effect of real exchange rate volatility on Egypt's trade balance (1980–2010). It applies unit root tests, cointegration, and ECM to analyze long- and short-term effects. Results show a long-run relationship, with volatility having a negative impact on trade. It suggests stabilizing the exchange rate to improve trade outcomes.

Comment: A solid empirical attempt to link exchange rate volatility with trade performance over a long historical period. The use of both long- and short-term analysis (ECM) is a strength.

Research Gap: The study lacks differentiation between types of trade (e.g., exports vs. imports), and does not examine how exchange rate risk management practices by firms may moderate these effects.

Selim (2008): This study assesses the impact of external shocks (e.g., trade deterioration, industrial slowdown, borrowing costs) on Egypt's economy (1983–2006). It uses regression and unrestricted VAR models. Findings show external shocks significantly affect key macroeconomic variables. Foreign aid and monetary policy helped cushion the negative effects. Internal shocks were less influential

Comment: An early and useful analysis of external shocks on Egypt's macroeconomy, highlighting the role of

foreign aid and policy response mechanisms.

Research Gap: The study is relatively outdated and does not reflect the major structural changes in the global and Egyptian economies post-2011. It also omits the role of financial integration and political instability.

Research Gap: There is no study examining the impact of economic shocks on the exchange rate of the Egyptian pound, which limits a comprehensive understanding of the factors driving monetary instability in Egypt."

3- Basics of Exchange Rate

3-1 - Exchange rate: It is the value of a currency when exchanged for another currency (Burton & others, 1991),

2-2 Methods of displaying the exchange rate:

3-2-1 Direct method: It is the number of units of foreign currency required to obtain one unit of local currency (Edwards, 1989)

3-2-2 Indirect method: It is the number of units of local currency equivalent to one unit of foreign currency. (Edwards, 1989)

3-3 Types of exchange rate

3-3-1 Nominal Exchange Rate: It is a measure of the exchange of one country's currency with another country's currency, without taking into account price level differences between countries.

3-3-2 Real exchange rate: It is a measure of the exchange of one country's currency with another country's currency, taking into account price level differences between countries, and expresses the number of units of foreign goods needed to purchase one unit of local currency. It is calculated by adjusting the nominal exchange rate using local and foreign price indices. It is calculated as follows: (Krugman & Others, 2022)

$$RER = \frac{\text{Nominal Exchange Rate} \times \text{Foreign Price Level}}{\text{Domestic Price Level}}$$

The Real Effective Exchange Rate is a weighted average of the real exchange rates between a country's currency and the currencies of other countries, Trade exchange ratios between these countries are used as weights for this weighting. The change in the real effective exchange rate reflects the extent of improvement or deterioration in the value of the local currency relative to a basket of other currencies. (Hyder & Mahboob, 2006)

3-3-4 Equilibrium Exchange Rate:

It is the price that is achieved when the quantities demanded are equal to the quantities supplied of a country's currency, regardless of the impact of speculation and unusual capital movements. It is a price that is consistent with the overall economic equilibrium, so that a sustainable balance of payments is achieved and when the economy is growing at a normal rate, there is an internal balance in the local economy and an external balance in foreign transactions at the same time. It is the price that prevails in a stable economic environment. (Krugman, 1990)

3-4 Exchange rate systems:

3-4-1 Fixed Exchange Rate System: In this system, the value of the local currency is linked to a single foreign currency (such as the US dollar) or a basket of currencies. Monetary authorities undertake to maintain the fixed exchange rate by intervening in foreign exchange markets. Key advantages include monetary stability and reduced risks of exchange rate volatility, Its disadvantages include restrictions on local monetary policy and exposure to market speculation. (Obstfeld & Rogoff, 1996)

3-4-2 Flexible Exchange Rate System: This system allows market forces (supply and demand) to determine the exchange rate without direct intervention from monetary authorities. The exchange

rate changes daily based on economic movements. Its advantages include flexibility in facing economic shocks and independence of monetary policy. "Disadvantages include significant exchange rate volatility and heightened risks of abrupt changes. (Krugman & Others, 2022)

3-4-3 Managed Float Exchange Rate System: This system combines a fixed and flexible system, as it allows the market to determine the exchange rate, but monetary authorities intervene when necessary to avoid excessive fluctuations or to maintain the stability of the currency. Its advantages include achieving relative stability with limited flexibility, while maintaining economic competitiveness. Its disadvantages include challenges in determining when and how to intervene, and being vulnerable to market pressures. (Mishkin, 2021))

3-5 Exchange Rate Theories: One of the most important exchange rate theories: (Mishkin, 2021)

2-5-1 Purchasing Power Parity Theory (PPP): This theory states that the nominal exchange rate between two currencies should equal the ratio of price levels between the two countries. If price levels change in one of the two countries, the nominal exchange rate is expected to change to compensate for this difference.

2-5-2 Balance of Payments Theory: It indicates that the exchange rate is determined based on the supply and demand for the currency in the foreign exchange market, which is mainly affected by factors such as exports, imports, and capital movements.

3-5-3 Asset Approach: This theory focuses on future expectations regarding currencies as financial assets. Investors treat currencies as investment instruments and base their decisions on anticipated returns

3-5-4 Open Market Theory: This theory explains that the exchange rate is

determined based on the interaction between supply and demand in the open market, and is influenced by factors like interest rates and inflation.

3-6- Exchange rate determinants: There are many variables that affect the exchange rate, and they reflect the various economic, political, and psychological factors that play a role in determining the value of the national currency against foreign currencies. Each variable directly and indirectly affects the exchange rate, with the strength of its influence varying based on the economy's nature and the policies implemented. These variables can be classified as follows:

2-6-1 Economic factors:

2-6-1-1 Gross Domestic Product (GDP): Reflects the economic performance of the country. A high GDP indicates a strong economy, which supports the national currency. (Mankiw, 2020))

3-6-1-2 Total Domestic Investment: Increasing domestic investment strengthens the national economy and increases demand for the national currency, which supports its value. (Mishkin, 2021).

3-6-1-3 Foreign Direct Investment (FDI): FDI flows into the country lead to increased demand for the national currency and an increase in its value. (Dunning, 2008).

3-6-1-4 Indirect Foreign Investment: Includes portfolio investments in stocks and bonds. The inflow of such investments enhances the national currency's value, but their effects are more volatile than those of direct investments (Shleifer, 2000).

3-6-1-5 Inflation: High inflation erodes the currency's value relative to foreign currencies. (Krugman & Wells, 2020)

3-6-1-6 Interest rates: Currencies with high interest rates are more attractive

to investors, raises their value. Mishkin, 2021))

3-6-1-7 External debt: High external debt leads to weak confidence in the economy, which negatively affects the value of the currency (Reinhart & Rogoff, 2009).

3-6-1-8 Debt servicing costs: High debt servicing expenses drain foreign exchange reserves, weakening the national currency's value. (Cline, 1995)

3-6-1-9 Trade balance: Trade deficit (excess imports over exports) leads to a decrease in the value of the national currency due to high demand for foreign currencies. (Krugman & Obstfeld, 2017).

3-6-1-10 Economic policies: Policies that support economic growth, such as controlling inflation and managing public debt, have a positive effect on the currency. (Rodrik, 2011)) Eichengreen, 2008))

3-6-1-11 Monetary and financial factors:

3-6-1-11-1 International reserves: The presence of sufficient foreign exchange and gold reserves enhances the stability of the national currency. (Obstfeld & Rogoff, 1996).

3-6-1-11-2 Monetary policies: Central bank interventions, such as adjusting interest rates or intervening directly in currency markets, influence the exchange rate. (Taylor & Woodford, 2011).

3-6-2 Political factors

3-6-2-1 Political stability: Countries with a stable political climate attract foreign investment, which enhances the value of the national currency. (Rodrik, 2011))

3-6-3 Psychological and Market Factors

3-6-3-1 Market expectations: Traders' perceptions about a currency's

future performance can cause immediate fluctuations in the exchange rate. (Shleifer, 2000)

3-6-3-2 Supply and Demand: Increased demand for the currency or increased supply directly affects its value. (Copeland, 2014)

3-6-4 External and International Factors:

3-6-4-1 Oil and commodity prices: The currencies of countries exporting oil or other commodities are influenced by the fluctuations in the prices of these products. (Hamilton, 2009).

3-6-4-2 Global financial crises: Such crises drive capital flows to safe-haven assets, adversely impacting the currencies of affected countries. (Reinhart & Rogoff, 2009)

4- Basics of Shocks:

4-1 The Concept of Shocks: Economic shocks are unexpected events that significantly affect economic activities, whether at the state or global level. (Blanchard & Johnson, 2017).

4-2 Types of shocks and their classifications: The types of shocks vary according to the criterion used for classification.

4-2-1 Shocks according to the source criterion: They are divided into external shocks and internal shocks. (Obstfeld & Rogoff, 1996).

4-2-1-1 External shocks: are events that arise outside the local economy and affect it, including:

Global commodity price shocks: sharp changes in the prices of oil, minerals, or agricultural products.

Global economic crises, such as the 2008 crisis or the Corona pandemic, and fluctuations in international trade, which are changes in demand or supply in foreign markets, and global financial crises

4-2-1-2 Internal shocks: These are shocks that arise within the local economy and include: Economic policy shocks: major changes in monetary or financial policies (such as the decision to float the currency), and natural or political disasters, such as earthquakes or political unrest.

4-2-2 Shocks according to the impact on the economy: Shocks are divided according to the economic impact criterion into supply shocks and demand shocks. (Mankiw, 2020)

4-2-2-1 Supply shocks: These disruptions impact the economy's production capacity for goods and services. They include: Increased production costs, such as increased energy prices, and disruptions in supply chains. They include Increased production costs, such as higher energy prices, and disruptions in supply chains resulting from wars or natural disasters.

4-2-2-2 Demand shocks: These disruptions influence consumers' or investors' willingness to spend or invest, including:

Changes in fiscal policies: sudden increases in taxes or government spending, and changes in consumer behavior, such as decreased consumption during crises.

4-2-3 Shocks according to the time period: Shocks are divided according to the time period into short-term shocks and long-term shocks. (Barro & Sala, 2004)

4-2-3-1 Short-term shocks: These are sudden events that affect for a limited period of time. Example: temporary fluctuations in exchange rates.

4-2-3-2 Long-term shocks: These are sustained changes in the economy that lead to a restructuring of economic activities. Example: economic transformation following the discovery of new natural resources.

4-3 The impact of shocks on the exchange rate of the Egyptian pound: Shocks influence the Egyptian pound's

exchange rate either directly or indirectly by affecting its determinants

4-3-1 The most important shocks on the exchange rate of the Egyptian pound: The following are the most important shocks that affected the exchange rate of the Egyptian pound: (Dornbusch, et al., 2010; Barro & Sala, 2004)

4-3-1-1 External shocks: These represent events that arise outside the Egyptian economy and affect it due to its openness to trade and global markets. The most important of these are (Obstfeld & Rogoff, 1996)

4-3-1-1-1 Oil price shocks: (Ebrahim & El-Sharif, 2020; Baumeister & Kilian, 2016; Arezki & Blanchard, 2014; Kilian, 2009; Hamilton, 2013)

4-3-1-1-1-1 Oil Price Shocks 1980s: Global oil prices experienced significant fluctuations that affected Egypt as an oil producing and importing country. The sharp drop in oil prices in 1986 reduced revenues for the Gulf countries, reducing remittances from Egyptians working there.

4-3-1-1-1-2 Oil Price Shocks 1990-1991 (Gulf War): High oil prices during the war increased the cost of energy imports, putting pressure on foreign reserves and the exchange rate.

4-3-1-1-1-3 Oil price shocks after 2011: The unrest in the Arab region impacted Egyptian oil and gas exports, increased reliance on costly imports, and disrupted the region's economic and political stability, leading to reduced investment flows and heightened pressure on the Egyptian pound

4-3-1-1-2 Global economic crises: (Mankiw, 2020).

4-3-1-1-2-1 The global financial crisis (2008) caused a decrease in foreign direct investment flows to Egypt and a decline in tourism revenues, which led to significant pressure on foreign reserves and the exchange rate.

4-3-1-1-2-2 Corona pandemic

(2020): The pandemic caused a near-total halt in Egyptian tourism, reduced remittances from expatriate workers, and the withdrawal of foreign portfolio investments from the Egyptian market, resulting in a significant devaluation of the pound.

4-3-1-1-2-3 The Russian-Ukrainian War:

The Russian-Ukrainian war had several effects, the most important of which are: (Arezki & Bruckner, 2022; World Bank, 2022; Frieden & Lake, 2005; Kilian & Murphy, 2022; Blanchard & Johnson, 2017).

4-3-1-1-2-3-1 Direct impact through economic channels:

This is through Rising commodity prices: Russia and Ukraine are among the largest exporters of wheat and grains in the world. With the outbreak of the war, wheat prices rose significantly, which led to an increase in the cost of importing wheat for Egypt, which is the largest importer of wheat in the world, and this increase in import costs affected the Egyptian balance of payments, which led to increased pressure on the Egyptian pound. Supply chain disruptions: Regional conflicts (such as wars) caused difficulties in sourcing raw materials, negatively affecting the economy and exchange rate stability.

Increased energy prices: The wars have driven global oil and gas prices higher, raising the cost of Egypt's energy imports. Although Egypt is a gas producer, its dependence on imports, in turn, the exchange rate of the Egyptian pound.

4-3-1-1-2-3-2 Indirect impact through financial flows:

-Foreign capital outflows (hot money flight): Rising global uncertainty and increased US interest rates triggered significant capital outflows from emerging markets, including Egypt. The exit of these flows has led to a severe shortage of foreign currencies increased pressure on the Egyptian pound.

Declining tourism revenues: Russia and Ukraine are among the largest sources of inbound tourism to Egypt, and the war has led to a sharp decline in the number of tourists from these two countries, affecting Egypt's foreign exchange revenues.

Increased inflationary pressures: The war led to a rise in the prices of food and energy commodities locally, which increased inflation rates. The rise in inflation reduced the pound's purchasing power and exacerbated the trade deficit.

Impact on monetary reserves: To contain the repercussions of the crisis, the Central Bank depleted part of its foreign reserves to support the Egyptian pound and stabilize the market, and this decline subsequently led to the exchange rate being moved several times.

4-3-1-1-2-3-3 Decisions of the Egyptian government and the Central Bank

Moving the exchange rate: In response to foreign currency shortages and pressure on the pound, the Central Bank of Egypt adjusted the exchange rate in March and October 2022, leading to a significant decline in the value of the pound against the US dollar.

Agreement with the International Monetary Fund (2022): To obtain new financial support, the government further liberalized the exchange rate as part of the agreement, which led to an additional decline in the value of the pound.

4-3-1-1-2-3-4 Summary of the results of the Russian-Ukrainian war

- The devaluation of the Egyptian pound: The currency's value has dropped significantly since the war began in February 2022, with the dollar's value nearly doubling against the pound during this period.

- Increased economic pressures: The cost of living has risen, with increasing reliance on imports in foreign currencies.

- Strengthening economic reforms: The crisis prompted the government to take steps to boost local production and reduce reliance on imports.

4-3-1-2 Internal shocks: Internal shocks result from local events such as political changes, natural disasters, or major economic decisions, the most important of which are:

4-1-2-1 Political and social changes (Alesina & Perotti, 1996).

4-3-1-2-1-1 The January 2011 revolution: It led to a significant decrease in foreign reserves due to the flight of investments and the decline in tourism, which caused the value of the pound to deteriorate. These effects continued for years due to the state of instability.

4-3-1-2-1-2 The 2013 revolution and its aftermath: Markets were affected by political uncertainty, which increased pressure on the pound.

4-3-1-2-2- Monetary and fiscal policies (Blanchard & Johnson, 2017)

Floating the pound in 2003: The decision to liberalize the exchange rate aimed at ensuring stability but resulted in a depreciation of the pound, leaving the market with ongoing challenges."

Economic reforms (2016): The reform program in cooperation with the International Monetary Fund included liberalizing the exchange rate, reducing subsidies, and increasing taxes. Although these reforms increased pressure on citizens in the short term, they helped improve foreign reserves and made the economy more resilient.

Floating the pound in 2016: As part of the economic reform program with the International Monetary Fund, the exchange rate was fully liberalized, causing a sharp initial depreciation of the pound against the dollar, yet improving foreign reserves over time.

5- Econometric Study

5-1 The study relied on World Bank data during the period (1977-2022) and the following variables were studied:

Table (1): Study Variables of Study

Name	Indicator
Official exchange rate (local currency against the US dollar, average period)	Y1
Total external debt balance (due and disbursed debt, at current US dollar prices)	X1
Total reserves (including gold, at current US dollar prices)	X2
Inflation, GDP deflator (% annual)	X3
Gross capital formation (% of GDP)	X4
Inflation, GDP deflator (% annual) - States	X5

Table No. (2): Pearson partial correlation coefficient

		Correlations					
		Y1	X1	X2	X3	X4	X5
Y1	Pearson Correlation	1	.864**	.845**	.094	-.638-**	-.249
	Sig. (2-tailed)		.000	.000	.535	.000	.096
	N	46	45	46	46	46	46
X1	Pearson Correlation	.864**	1	.676**	.072	-.364-*	-.285
	Sig. (2-tailed)	.000		.000	.636	.014	.058
	N	45	45	45	45	45	45
X2	Pearson Correlation	.845**	.676**	1	-.045	-.678-**	-.448-**
	Sig. (2-tailed)	.000	.000		.765	.000	.002
	N	46	45	46	46	46	46
X3	Pearson Correlation	.094	.072	-.045	1	.241	.150
	Sig. (2-tailed)	.535	.636	.765		.107	.318
	N	46	45	46	46	46	46
X4	Pearson Correlation	-.638-**	-.364-*	-.678-**	.241	1	.586**
	Sig. (2-tailed)	.000	.014	.000	.107		.000
	N	46	45	46	46	46	46
X5	Pearson Correlation	-.249	-.285	-.448-**	.150	.586**	1
	Sig. (2-tailed)	.096	.058	.002	.318	.000	
	N	46	45	46	46	46	46

** . Correlation is significant at the 0.01 level (2-tailed).
* . Correlation is significant at the 0.05 level (2-tailed).

- There is a strong direct correlation (0.864) between the value of the dollar denominated in local currencies and the total external debt balance (debt due and disbursed, at current dollar prices) at a significance level close to zero. This indicates that an increase in the total external debt balance leads to a

depreciation of the Egyptian pound, which aligns with economic theory.

- denominated in local currencies and total reserves (including gold, at current

US dollar prices) at a significance level close to zero. This means that an increase in total reserves (including gold, at current US dollar prices) leads to a depreciation of the Egyptian pound, which aligns with economic theory.

- There is a strong inverse correlation (-0.638) between the value of the dollar denominated in local currencies and gross capital formation (% of GDP) at a significance level close to zero. This means that an increase in gross capital formation (% of GDP) leads to an appreciation of the

Egyptian pound, which aligns with economic theory.

- There is a weak inverse correlation (-0.249) between the value of the dollar denominated in local currencies and inflation (GDP deflator, annual %) in the United States, at a significance level of 0.096. This suggests that inflation, measured by the GDP deflator (annual %), leads to a reduction in the dollar exchange rate and an appreciation of the Egyptian pound, which aligns with economic theory.

- There is a strong direct correlation (0.676) between the total external debt balance (debt due and disbursed, at current US dollar prices) and total reserves (including gold, at current US dollar prices) at a significance level close to zero. An increase in external debt balances (% of gross national income) leads to an increase in total reserves (including gold, at current US dollar prices), reflecting the use of external debt to obtain foreign currency and enhance foreign exchange reserves.

- There is a weak inverse correlation (-0.364) between the total external debt balance (debt due and disbursed, at current US dollar prices) and gross capital formation (% of GDP) at a significance level of 0.014. This indicates that an increase in gross capital formation (% of GDP) reduces the total external debt balance (debt due and disbursed, at current US dollar prices).

- There is a weak inverse correlation (-0.285) between the total external debt balance (debt due and disbursed, at current US dollar prices) and inflation (GDP deflator, annual %) in the United States, at a significance level of 0.058, which is not statistically significant at the 5% level.

- There is a strong inverse correlation (-0.678) between total reserves (including gold, at current US dollar prices) and gross capital formation (% of GDP) at a significance level close to zero.

- There is a moderate inverse correlation (-0.678) between total reserves (including gold, at current US dollar prices) and inflation (GDP deflator, annual %) in the United States, at a significance level of 0.002.

-There is a moderate direct correlation (0.586) between inflation (consumer prices, %) in the United States and gross capital formation (% of GDP) in Egypt, at a significance level close to zero. An increase in inflation (consumer prices, %) in the United States leads to an increase in gross capital formation (% of GDP) in Egypt, as it serves as an indicator of increased demand, rising prices, and higher profits, which aligns with economic theory.

5-3 Methodology of Vector Autoregressive (VAR) Models

Sims introduced the Vector Autoregressive (VAR) model in 1980 as an alternative to structural models, which involve many arbitrary decisions, considered a weakness of these models. A true contemporaneous relationship requires treating the variables in the model equally without prior distinction between endogenous and exogenous variables. Furthermore, forecasting using VAR models is more accurate than using traditional structural models. Structural models are less precise in out-of-sample predictions, likely due to constraints imposed on them. The Ordinary Least Squares (OLS) method can be applied to estimate each equation in a VAR model individually. VAR models are also more flexible than other models, as they allow the value of a variable to depend on more than just its lagged values or a combination of white noise disturbances (Christopher, 1980) (Gujarati, 2003) (Chris Brooks, 2008).

Despite the advantages of VAR models, they have some challenges and limitations, including:

1. The variables in the model must be stationary. If not, the data must be transformed to first differences. If the model contains a mix of I (0) and I (1) variables, transforming the data becomes complex.

2. VAR models are not grounded in economic theory; there are no restrictions on the model's parameters, meaning each variable can cause the other. However, statistical tests can estimate the model and eliminate insignificant parameters to align the model with theory.

3. The large number of parameters that need interpretation.

4. Using lag periods reduces the degrees of freedom.

5-3-1 Boulding Step Model

5-3-1-1 Unit Root Test: This test examines the stationarity of time series. Several tests are commonly used, including:

5-3-1-1-1 Augmented Dickey-Fuller (ADF) Test: (Dickey and Fuller, 1979)

Developed by Dickey and Fuller in 1979, this test is based on: (Chris Brooks, 2008)

the null hypothesis ($\phi=1$), that is there is a unit root

$$y_t = \phi y_{t-1} + u_t$$

the alternative hypothesis ($\phi < 1$) indicates stationarity (no unit root). Another form of the test equation is: $y_t = \psi y_{t-1} + u_t$

Where $\phi=1$ implies $\psi=0$. The test can include a constant term, a time trend, both, or neither. The equation for the unit root test becomes: (Chris Brooks, 2008)

$$y_t = \phi y_{t-1} + \mu + \lambda t + u_t$$

After subtracting y_{t-1} from both sides:

$$\Delta y_t = \psi y_{t-1} + \mu + \lambda t + u_t$$

The test uses critical values to determine stationarity: (Dickey and Fuller, 1981) (Chris Brooks, 2008)

$$\text{test statistics} = \frac{\hat{\psi}}{SE\hat{\psi}}$$

If u_t is white noise, this test is valid. Otherwise, if there is serial correlation in the dependent variable y_t , the Augmented Dickey-Fuller (ADF) test is used, incorporating lagged differences: (Dickey and Fuller, 1981)

$$\Delta y_t = \psi y_{t-1} + \sum_{i=1}^p \alpha_i \Delta y_{t-i} + u_t$$

5-3-1-1-2 Phillips-Perron (PP) Test
This test is similar to the ADF test but includes automatic adjustments to handle serial correlation in residuals. It uses non-parametric statistical methods without adding lagged differences. The unit root test equation is estimated using OLS (Dickey and Fuller, 1981) (Paulo . And Other, 2013)

$$x_t = \alpha x_{t-1} + u_t$$

5-3-1-1-3 Kwiatkowski-Phillips-Schmidt-Shin (KPSS) Test
This test addresses weaknesses in the previous tests when autocorrelation and heteroskedasticity are present. Unlike the previous tests, the null hypothesis assumes stationarity, while the alternative hypothesis indicates non-stationarity. The test statistic is based on the Lagrange Multiplier (LM) as follows: (Kwiatkowski And Other, 1992) (Kozhan , 2010).

$$KPSS = \left(\frac{1}{S_t^2}\right) * \left(\sum_{t=1}^T \frac{\hat{S}_t^2}{n^2}\right)$$

Where u_t are residuals, and S_t^2 represents the long-term variance of the residuals. The test can include a constant, a trend, or both.

5-3-1-2 Optimal Lag Length Selection

The optimal lag length ensures no residual autocorrelation in the VAR model. It is determined using criteria such as: (Schwarz, 1975) (Roberts And Nord, 1985) (Cromwell And Other, 1994) (Chris Brooks, 2008).

• Akaike Information Criterion (AIC):

$$MAIC = \text{Log} \left| \widehat{\Sigma} \right| + \frac{2K'}{T}$$

Schwarz Bayesian Information Criterion (SBIC):

$$MSBIC = \text{Log} \left| \widehat{\Sigma} \right| + \frac{K'}{2} \log(T)$$

Hannan-Quinn Information Criterion (HQIC):

$$MHQIC = \text{Log} \left| \widehat{\Sigma} \right| + \frac{K'}{2} \log(\log(T))$$

Where Σ is the residual variance-covariance matrix, T is the number of observations, and K' is the number of parameters. The criterion with the smallest value determines the optimal lag length.

5-3-1-4 Estimation of the VAR Model

The VAR model can be formulated as: (Sheikhi, 201) :(Shumway and Stoffer, 2006)

$$y_t = \varphi_0 + \Phi_1 y_{t-1} + \dots + \Phi_p y_{t-p} + \varepsilon_t$$

Where y_t is a vector of length k , p is the VAR order, Φ are coefficient matrices, and ε_t represents random vectors with a full-rank covariance matrix.

5-3-1-5 Granger Causality Test: (GRANGER, 1988) (GRANGER and Others, 2000).

This test determines whether one variable (independent) causes another (dependent) using the F-test. The hypotheses are:

Null hypothesis (H0): The independent variable does not cause the dependent variable.

Alternative hypothesis (H1): The independent variable causes the dependent variable.

If p -value < 0.05 , reject H0; otherwise, accept it.

5-3-1-6 Impulse Response Function (IRF)

The IRF evaluates the dynamic response of the dependent variable to shocks in the independent variable over time, tracking the directional responses resulting from a one-unit standard deviation shock. (Kilian. and Ivanov, 2005)

5-3-1-7 Variance Decomposition:

Variance decomposition explains the contribution of each shock to the forecast error variance in the dependent variables. This method uses Choleski decomposition to trace the proportion of variance caused by unexpected shocks over time. (Kilian. and Ivanov, 2005)

5-3-1-7 Johansen Cointegration Test and VECM: (

The Johansen test identifies the number of cointegrating vectors, with two statistics:

Trace Statistic (λ Trace): (Hallam and Zanolli, 1993) (Hjalmarsson and Osterholm, 2007) (Johansen, 1988) (Johansen and Juselius, 1990) (Davidson and MacKinnon, 1993) (Hjalmarsson and Osterholm, 2007) (Yooo, 2006) (Hamilton, 1994).

$$\lambda_{Trace}(r) = -T \sum_{i=r+1}^g \ln (1 - \hat{\lambda}_i)$$

Maximum Eigenvalue Statistic (λ Max):

$$\lambda_{max}(r, r + 1) = -T \ln(1 - \hat{\lambda}_{r+1})$$

The Vector Error Correction Model (VECM) ensures short-term dynamics align with long-term equilibrium

5-3-2 Econometric model results

5-3-2-1 Unit Root Test

The KPSS test was used, and the results are presented in the following table:

$$\Delta Z_t = \alpha + \sum \beta_i \Delta Z_{t-i} + \lambda u_{t-1} + e_t$$

Where λ (error correction term) must be negative and significant to confirm long-term equilibrium.

Table (3): Unit Root Test Results at Level (I=0)

NO	Variable	Kwiatkowski-Phillips-Schmidt-Shin test statistic	Asymptotic critical values*:			Exogenous	Decision
			1% level	5% level	10% level		
						Constant	
1	Y	0.116929	0.216	0.146	0.119	Constant, Linear Trend	stationary $\alpha=1\%$
2	X1	0.127750	0.216	0.146	0.119	Constant, Linear Trend	stationary $\alpha=1\%$
3	X2	0.162090	0.216	0.146	0.119	Constant, Linear Trend	stationary $\alpha=1\%$
4	X3	0.163943	0.739	0.463	0.347	Constant	stationary $\alpha=1\%$
5	X4	0.102527	0.216	0.146	0.119	Constant, Linear Trend	stationary $\alpha=1\%$
6	X5	0.18948 0.190145 9	0.216	0.146	0.119	Constant, Linear Trend	stationary $\alpha=1\%$

Source: *EViews12 outputs based on World Bank data for the period 1977-2022, Available at: World Bank Indicator (Accessed on 1/10/2024).*

From the table above, it is clear that all variables are stable at the level, with a significance level of 1%.

5-3-2-2 Optimal Lag Length

Table (4): Optimal Lag Length

VAR Lag Order Selection Criteria
 Endogenous variables: LN_Y LN_X1 LN_X2 LN_X3 LN_X5
 Exogenous variables: C
 Date: 12/08/23 Time: 21:11
 Sample: 1977 2022
 Included observations: 36

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-122.1156	NA	0.000803	7.061980	7.281913	7.138742
1	31.64538	256.2683*	6.38e-07*	-0.091410	1.228189*	0.369166*
2	57.98619	36.58447	6.45e-07	-0.165900*	2.253365	0.678489
3	82.47955	27.21484	8.37e-07	-0.137753	3.381178	1.090449
4	104.9370	18.71453	1.60e-06	0.003501	4.622098	1.615515

* Indicates lag order selected by the criterion
 LR: sequential modified LR test statistic (each test at 5% level)
 FPE: Final prediction error
 AIC: Akaike information criterion
 SC: Schwarz information criterion
 HQ: Hannan-Quinn information criterion

Source: EVIEWS12 outputs based on World Bank data for the period 1977-2022, Available at: World Bank Indicator (Accessed on 1/10/2024).

The optimal lag length is one period according to SC and HQ criteria, three periods according to LR and FPE criteria, and two periods according to AIC. Therefore, the optimal lag length is **two periods**.

5-3-2-3 VAR Model Estimation

Table (5): Vector Autoregression Model (VAR) Estimates

Vector Autoregression Estimates					
Date: 12/08/23 Time: 21:13					
Sample (adjusted): 1979 2021					
Included observations: 40 after adjustments					
Standard errors in () & t-statistics in []					
	LN_Y	LN_X1	LN_X2	LN_X3	LN_X5
LN_Y(-1)	1.300445 (0.20526) [6.33555]	0.080588 (0.10861) [0.74196]	0.449587 (0.19181) [2.34388]	0.637325 (0.61927) [1.02916]	0.166010 (0.39535) [0.41991]
LN_Y(-2)	-0.237454 (0.24389) [-0.97360]	0.112217 (0.12906) [0.86953]	-0.147697 (0.22791) [-0.64804]	-0.517358 (0.73582) [-0.70311]	-0.254818 (0.46976) [-0.54245]
LN_X1(-1)	-0.326621 (0.34430) [-0.94867]	1.245729 (0.18218) [6.83777]	-0.313698 (0.32174) [-0.97501]	0.808685 (1.03873) [0.77853]	1.082823 (0.66314) [1.63287]
LN_X1(-2)	0.343741 (0.33946) [1.01260]	-0.366329 (0.17963) [-2.03940]	0.259018 (0.31722) [0.81652]	-0.967560 (1.02415) [-0.94475]	-0.954274 (0.65383) [-1.45951]
LN_X2(-1)	-0.046953 (0.17639) [-0.26619]	-0.172461 (0.09333) [-1.84778]	1.026210 (0.16483) [6.22591]	-0.216827 (0.53215) [-0.40745]	0.152368 (0.33973) [0.44849]
LN_X2(-2)	-0.093297 (0.17615) [-0.52963]	0.018860 (0.09321) [0.20233]	-0.312638 (0.16461) [-1.89923]	-0.015713 (0.53145) [-0.02957]	-0.229126 (0.33929) [-0.67531]
	LN_Y	LN_X1	LN_X2	LN_X3	LN_X5
LN_X3(-1)	-0.035853 (0.06471) [-0.55403]	0.035944 (0.03424) [1.04969]	0.022386 (0.06047) [0.37019]	0.409962 (0.19524) [2.09982]	-0.162755 (0.12464) [-1.30579]
LN_X3(-2)	0.014126 (0.06478) [0.21805]	-0.004942 (0.03428) [-0.14418]	-0.059174 (0.06054) [-0.97747]	0.220914 (0.19545) [1.13030]	0.029638 (0.12478) [0.23753]
LN_X5(-1)	-0.063221 (0.11316) [-0.55869]	-0.055396 (0.05988) [-0.92514]	-0.131806 (0.10575) [-1.24645]	0.352682 (0.34140) [1.03305]	0.819860 (0.21795) [3.76162]
LN_X5(-2)	-0.046210 (0.11604) [-0.39821]	0.029357 (0.06140) [0.47810]	0.250484 (0.10844) [2.30986]	-0.540354 (0.35010) [-1.54342]	-0.288078 (0.22351) [-1.28888]
C	2.963191 (4.83154) [0.61330]	6.248284 (2.55661) [2.44397]	7.636230 (4.51498) [1.69131]	9.978280 (14.5766) [0.68454]	-0.646924 (9.30593) [-0.06952]

R-squared	0.972189	0.965857	0.978184	0.491593	0.624690
Adj. R-squared	0.962599	0.954084	0.970661	0.316281	0.495273
Sum sq. resids	1.060305	0.296885	0.925917	9.651040	3.933502
SE equation	0.191213	0.101180	0.178685	0.576883	0.368291
F-statistic	101.3763	82.03697	130.0285	2.804096	4.826948
Log likelihood	15.84891	41.30828	18.55946	-28.32127	-10.37056
Akaike AIC	-0.242445	-1.515414	-0.377973	1.966063	1.068528
Schwarz SC	0.221996	-1.050972	0.086469	2.430505	1.532970
Mean dependent	1.316284	24.40024	23.22855	2.221352	0.803299
SD dependent	0.988728	0.472184	1.043191	0.697669	0.518397
Determinant resid covariance (dof adj.)		3.43E-07			
Determinant residual covariance		6.88E-08			
Log likelihood		46.05578			
Akaike information criterion		0.447211			
Black Criterion		2.769420			
Number of coefficients		55			

Source: EVIEWS12 outputs based on World Bank data for the period 1977-2022, Available at: World Bank Indicator (Accessed on 1/10/2024).

5-3-2-3-1 Diagnostic Tests for the Model

5-3-2-3-1-1 VAR Residual Serial Correlation LM Tests

Table (6): VAR Residual Serial Correlation LM Tests

VAR Residual Serial Correlation LM Tests						
Date: 12/08/23 Time: 21:15 Sample: 1977 2022 Included observations: 40						
Null hypothesis: No serial correlation at lag h						
Lag	LRE* stat	df	Prob.	Rao F-stat	df	Prob.
1	28.03366	25	0.3063	1.148125	(25, 75.8)	0.3153
2	18.03030	25	0.8411	0.695564	(25, 75.8)	0.8454
3	15.23081	25	0.9358	0.577927	(25, 75.8)	0.9378
Null hypothesis: No serial correlation at lags 1 to h						
Lag	LRE* stat	df	Prob.	Rao F-stat	df	Prob.
1	28.03366	25	0.3063	1.148125	(25, 75.8)	0.3153
2	48.53540	50	0.5323	0.947304	(50, 71.8)	0.5757
3	81.49941	75	0.2843	1.048232	(75, 52.1)	0.4332

*Edgeworth expansion corrected likelihood ratio statistic.

Source: EVIEWS12 outputs based on World Bank data for the period 1977-2022, Available at: World Bank Indicator (Accessed on 1/10/2024).

Conclusion: There is no serial correlation in the residuals.

5-3-2-3-2 VAR Residual Heteroskedasticity Tests

Table (7): VAR Residual Heteroskedasticity Tests (Levels and Squares)

VAR Residual Heteroskedasticity Tests (Levels and Squares)		
Date: 12/08/23 Time: 21:19 Sample: 1977 2022 Included observations: 40		
Joint test:		
Chi-sq	df	Prob.
293.0406	300	0.6022

Source: EVIEWS12 outputs based on World Bank data for the period 1977-2022, Available at: World Bank Indicator (Accessed on 1/10/2024).

Conclusion: Residuals exhibit homoscedasticity.

5-3-2-3-3. VAR Residual Normality Tests

Table (8): VAR Residual Normality Tests

VAR Residual Normality Tests				
Orthogonalization: Residual Correlation (Doornik-Hansen)				
Null Hypothesis: Residuals are multivariate normal				
Date: 12/08/23 Time: 21:23 Sample: 1977 2022 Included observations: 40				
Component	Skewness	Chi-sq	df	Prob.*
1	0.824693	4.932967	1	0.0263
2	-1.325078	10.53643	1	0.0012
3	-0.538744	2.306400	1	0.1288
4	-1.114125	8.085632	1	0.0045
5	0.533405	2.264254	1	0.1324
Joint		28.12569	5	0.0000
Component	Kurtosis	Chi-sq	df	Prob.
1	3.509063	0.388265	1	0.5332
2	5.360939	0.654619	1	0.4185
3	2.885991	0.194851	1	0.6589
4	4.414442	0.694996	1	0.4045
5	5.668323	12.58423	1	0.0004
Joint		14.51696	5	0.0126
Component	Jarque-Bera	df	Prob.	
1	5.321232	2	0.0699	
2	11.19105	2	0.0037	
3	2.501250	2	0.2863	
4	8.780628	2	0.0124	
5	14.84849	2	0.0006	
Joint		42.64265	10	0.0000

*Approximate p-values do not account for coefficient Estimation

Source: EVIEWS12 outputs based on World Bank data for the period 1977-2022, Available at: World Bank Indicator (Accessed on 1/10/2024).

At a 1% significance level:

- For **Model 1 and Model 3**, residuals are normally distributed based on Skewness, Kurtosis, and Jarque-Bera tests.
- For **Model 2**, residuals are normally distributed based on Kurtosis.
- For **Model 4**, residuals are normally distributed based on Kurtosis and Jarque-Bera.
- For **Model 5**, residuals are normally distributed based on Skewness.

5-3-2-4 Model Stability Test

Table (9): Model Stability Test

Roots of Characteristic Polynomial	
Endogenous variables: LN_Y LN_X1 LN_X2 LN_X3 LN_X5	
Exogenous variables: C	
Lag specification: 1 2	
Date: 12/08/23 Time: 21:37	
Root	Modulus
0.939131	0.939131
0.864839 - 0.163366i	0.880133
0.864839 + 0.163366i	0.880133
0.689839 - 0.380638i	0.787885
0.689839 + 0.380638i	0.787885
0.664790	0.664790
0.132325 - 0.552161i	0.567795
0.132325 + 0.552161i	0.567795
-0.188374	0.188374
0.012653	0.012653

No root lies outside the unit circle.
VAR satisfies the stability condition.

Source: EVIEWS12 outputs based on World Bank data for the period 1977-2022, Available at: World Bank Indicator (Accessed on 1/10/2024).

Conclusion: All roots lie inside the unit circle, confirming the stability of the VAR (1) model.

5-3-2-5 Wald Test

Table (10): Wald Test

Wald Test:			
Equation: Untitled			
Test Statistic	Value	df	Probability
F-statistic	109.8866	(9, 31)	0.0000
Chi-square	988.9794	9	0.0000

Null Hypothesis: C(1) = C(2)=C(3)=C(4)=C(5)=C(7)=C(8)=
C(9) = C(10)=C(11)

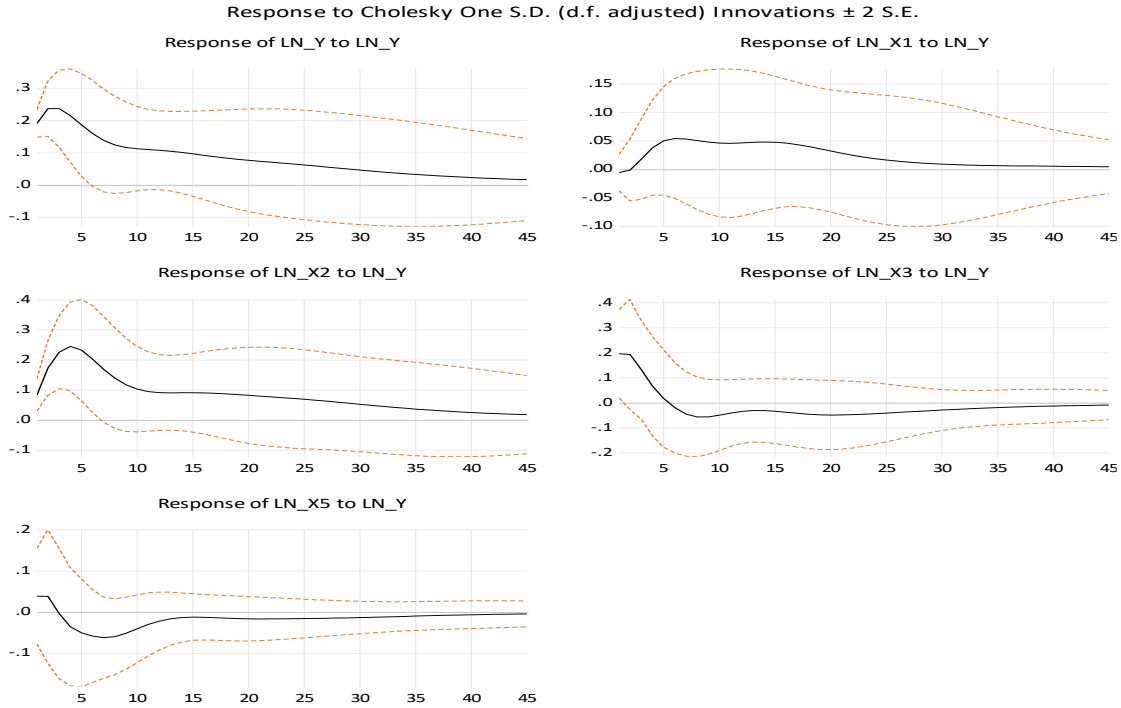
Source: EVIEWS12 outputs based on World Bank data for the period 1977-2022, Available at: World Bank Indicator (Accessed on 1/10/2024).

Conclusion: Since the p-value of Chi-Square is close to zero (less than 1%), we reject the null hypothesis and accept the alternative hypothesis. This implies that the coefficients are significant.

5-3-2-6 Dynamic Analysis of the VAR Model

5-3-2-6-1 Impulse Response Function (IRF)

Figure (1): Analysis of the impact of shocks on the variable LN_Y.



Source: EViews12 outputs based on World Bank data for the period 1977-2022, Available at: World Bank Indicator (Accessed on 1/10/2024).

Impact of Shocks on the Variable LN_Y

Effect of Shock in Exchange Rate LN_Y on Exchange Rate LN_Y:

A positive shock equivalent to one standard deviation in the exchange rate will improve the same variable during the same period. This effect increases in the second period, then gradually dissipates with a steep slope through the 10th period. The decline continues until it fully dissipates in the 45th period.

Effect of Shock in Total External Debt (Debt Outstanding and Disbursed, Current USD) LN_X1 on Exchange Rate LN_Y:

A positive shock equivalent to one standard deviation in total external debt (debt outstanding and disbursed, in current

USD) will reduce the dollar's exchange rate in the first and second periods. This signifies an improvement in the Egyptian pound exchange rate. However, the shock reverses its impact in the third period, leading to an increase in the dollar exchange rate and a depreciation of the Egyptian pound. The impact intensifies until the fifth period, stabilizes until the 15th period, and then gradually diminishes with a steep slope until the 25th period. The slope then declines further, causing the impact to dissipate slowly until it completely vanishes by the 30th period.

Effect of Shock in Total Reserves (Including Gold, Current USD) LN_X2 on Exchange Rate LN_Y:

A positive shock equivalent to one standard deviation in total reserves

(including gold and current USD) will cause a positive shock to the exchange rate, peaking in the fourth period. The impact then begins to fade steeply until the 10th period, stabilizes until the 20th period, and continues to dissipate gradually with a mild slope until it fully vanishes by the 45th period.

Effect of Shock in Inflation, GDP Deflator (Annual %, Local) LN_X3 on Exchange Rate LN_Y:

A positive shock equivalent to one standard deviation in inflation (GDP deflator, annual %) will cause a positive shock in the U.S. dollar exchange rate and a depreciation of the Egyptian pound. This shock peaks in the first period, stabilizes in the second, and dissipates until it fully vanishes by the fifth.

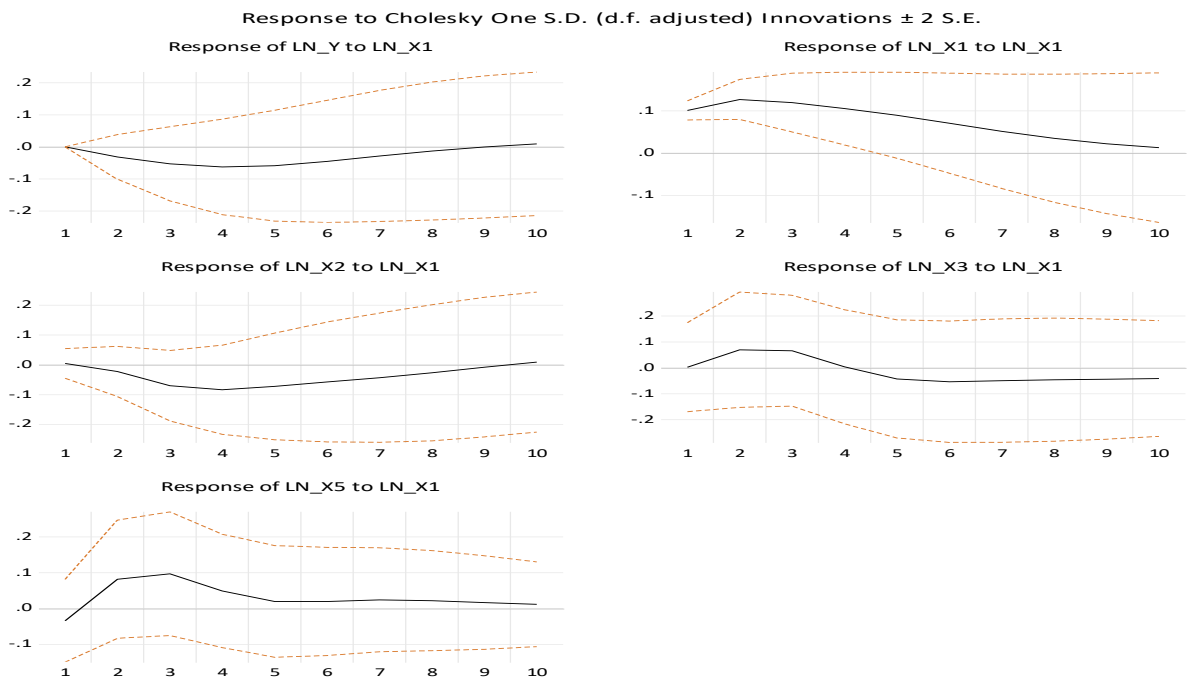
Effect of Shock in Inflation, GDP Deflator (Annual %, U.S.) LN_X3 on Exchange Rate LN_Y:

A positive shock equivalent to one standard deviation in U.S. inflation (GDP deflator, annual %) will cause a positive shock in the U.S. dollar exchange rate and a depreciation of the Egyptian pound. This shock peaks in the first period, stabilizes until the middle of the second period, then fades rapidly, vanishing completely by the fourth period.

Observation on Inflation Shocks (Local vs. Imported):

It is observed that both local and imported inflation shocks have similar patterns. However, during the study period, local inflation is more detrimental, with a longer memory and slower dissipation compared to imported inflation.

Figure (2): Impact of Shocks on the Variable LN_X1



Source: EVIEWS12 outputs based on World Bank data for the period 1977-2022, Available at: World Bank Indicator (Accessed on 1/10/2024).

Impact of Shocks on the Variable LN_X1

Effect of Shock in Exchange Rate LN_Y on Total External Debt (Debt Outstanding and Disbursed, Current USD) LN_X1:

A positive shock equivalent to one standard deviation in the U.S. dollar exchange rate will lead to a deterioration in total external debt (debt outstanding and disbursed, current USD) during the same period. The effect intensifies, reaching its peak in the fourth period, stabilizes until the sixth period, and then begins to dissipate. The shock vanishes completely by the ninth period. However, the effect continues to decline gradually with a steep slope until the 10th period and fully disappears by the 45th period.

Effect of Shock in Total External Debt (Debt Outstanding and Disbursed, Current USD) LN_X1 on LN_X1:

A positive shock equivalent to one standard deviation in total external debt (debt outstanding and disbursed, in current USD) will affect the same variable during the same period, peaking in the middle of the second period. The effect then slowly fades until it vanishes completely by the 10th period.

Effect of Shock in Total Reserves (Including Gold, Current USD) LN_X2 on Total External Debt (Debt Outstanding and Disbursed, Current USD) LN_X1:

A positive shock equivalent to one standard deviation in total reserves (including gold, current USD) will result in a positive shock in total external debt (debt outstanding and disbursed, current USD).

The effect peaks in the third period, stabilizes until the fourth period, then starts to dissipate steeply, disappearing entirely by the 10th period.

Effect of Shock in Inflation, GDP Deflator (Annual %, Local) LN_X3 on Total External Debt (Debt Outstanding and Disbursed, Current USD) LN_X1:

A positive shock equivalent to one standard deviation in inflation (GDP deflator, annual %) will cause a similar impact on total external debt (debt outstanding and disbursed, current USD). The effect begins in the first period, intensifies to its peak in the middle of the second period, then fades, vanishing completely by the fourth period.

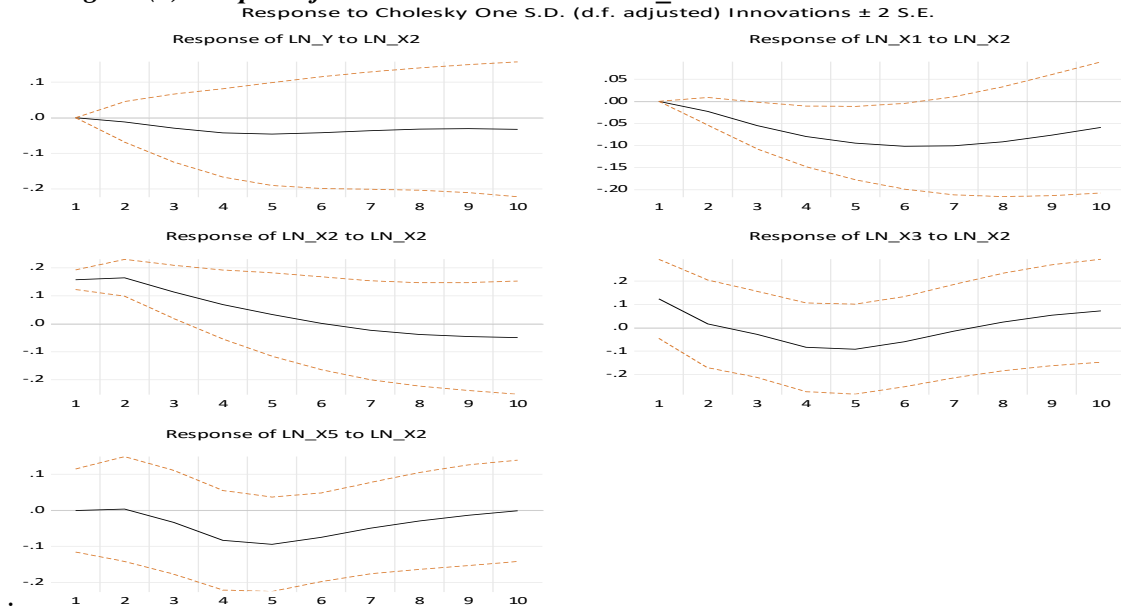
Effect of Shock in U.S. Inflation, GDP Deflator (Annual %, Imported) LN_X5 on Total External Debt (Debt Outstanding and Disbursed, Current USD) LN_X1:

A positive shock equivalent to one standard deviation in U.S. inflation (GDP deflator, annual %) will cause a positive shock in total external debt (debt outstanding and disbursed, current USD). The effect starts in the first period, intensifies to then begins to dissipate, nearly vanishing by the fifth period and completely disappearing by the 10th period.

Observation on Inflation Shocks (Local vs. Imported):

It is evident that the impact of imported U.S. inflation is more severe in its shocks on Egypt's total external debt compared to local inflation.

Figure (3) : Impact of Shocks on the Variable LN_X2



Source: *EIEWS12 outputs based on World Bank data for the period 1977-2022, Available at: World Bank Indicator (Accessed on 1/10/2024).*

Impact of Shocks on the Variable LN_X2

Effect of Shock in Exchange Rate LN_Y on Total Reserves (Including Gold, Current USD) LN_X2:

A positive shock equivalent to one standard deviation in the U.S. dollar exchange rate will lead to a deterioration in total reserves (including gold, current USD). The effect intensifies and fluctuations until the 15th period, after which it gradually fades and vanishes completely by the 30th period.

Effect of Shock in Total External Debt (Debt Outstanding and Disbursed, Current USD) LN_X1 on Total Reserves (Including Gold, Current USD) LN_X2:

A positive shock equivalent to one standard deviation in total external debt (debt outstanding and disbursed, current USD) will have an inverse impact on total reserves (including gold, current USD) during the same period. The effect peaks in the middle of the sixth period, stabilizes

until the eighth period, then begins to fade, vanishing completely by the 14th period.

Effect of Shock in Total Reserves (Including Gold, Current USD) LN_X2 on LN_X2:

A positive shock equal to one standard deviation in total reserves (including gold and current USD) will have a positive impact on the same variable. The effect peaks in the first period and continues until the middle of the second period, after which it fades and disappears by the seventh period.

Effect of Shock in Inflation, GDP Deflator (Annual %, Local) LN_X3 on Total Reserves (Including Gold, Current USD) LN_X2:

A positive shock equivalent to one standard deviation in inflation (GDP deflator, annual %, local) will have an inverse effect on total reserves (including gold and current USD). The effect period.

Effect of Shock in U.S. Inflation, GDP Deflator (Annual %, Imported) LN_X5 on Total Reserves (Including Gold, Current USD) LN_X2:

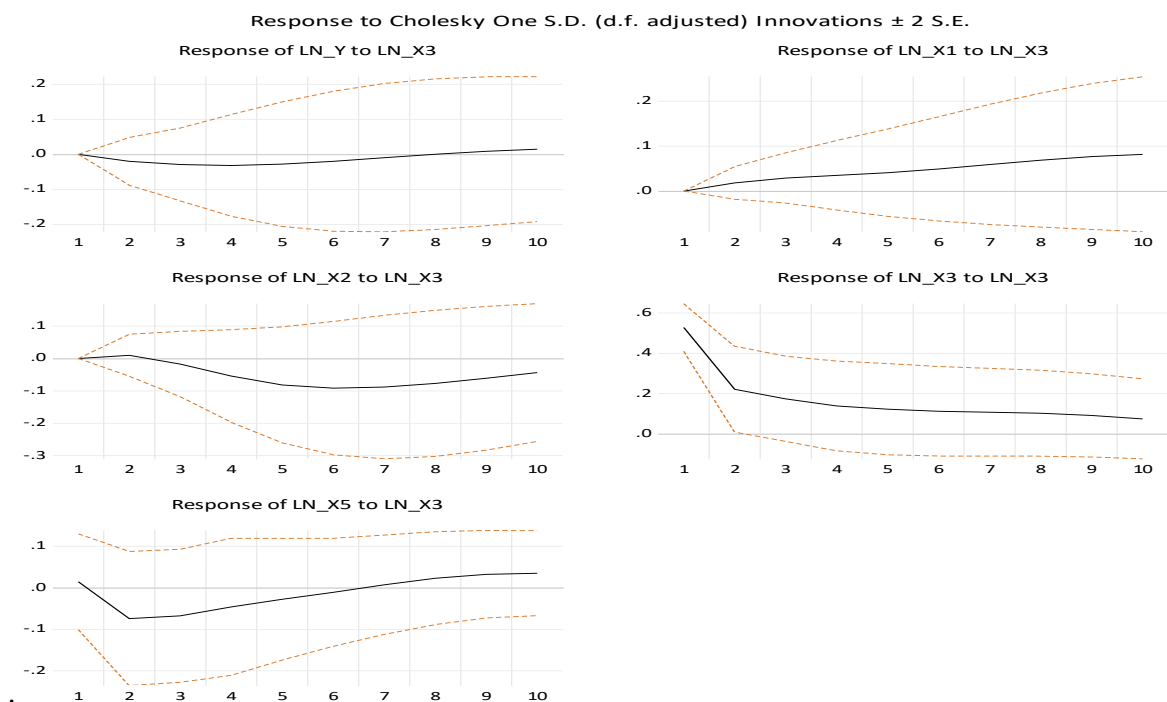
A positive shock equal to one standard deviation in U.S. inflation (GDP deflator, annual %) will have an inverse effect on total reserves (including gold and current USD). The effect begins in the middle of the second period, intensifies to its peak between the middle of the fourth

and fifth periods, and then fades, vanishing completely by the 10th period.

Observation on Inflation Shocks (Local vs. Imported):

It is noted that both local and (imported) U.S. inflation shocks have similar effects on total reserves (including gold and current USD). However, U.S. inflation shocks have a stronger and longer-lasting memory before fading completely.

Figure (4): Impact of Shocks on the Variable LN_X3



Source: EViews12 outputs based on World Bank data for the period 1977-2022, Available at: World Bank Indicator (Accessed on 1/10/2024).

Impact of Shocks on the Variable LN_X3

Effect of Shock in Exchange Rate LN_Y on Inflation, GDP Deflator (Annual %) LN_X3:

A positive shock equivalent to one standard deviation in the U.S. dollar exchange rate will lead to an inverse shock in the inflation (GDP deflator, annual %) LN_X3. The effect begins at the end of the first period, increases gradually to its peak at the end of the fourth period, and then

fades away progressively until it vanishes completely.

Effect of Shock in Total External Debt (Debt Outstanding and Disbursed, Current USD) LN_X1 on Inflation, GDP Deflator (Annual %) LN_X3:

A positive shock equivalent to one standard deviation in total external debt (debt outstanding and disbursed, current USD) will have a positive impact on inflation (GDP deflator, annual %). The effect begins gradually in the second period

and intensifies, peaking in the tenth period. It stabilizes until the 14th period, then gradually fades and vanishes completely by the 21st period.

Effect of Shock in Total Reserves (Including Gold, Current USD) LN_X2 on Inflation, GDP Deflator (Annual %) LN_X3:

A positive shock equal to one standard deviation in total reserves (including gold and current USD) will have an inverse effect on inflation (GDP deflator, annual %). The effect starts in the middle of the second period, intensifies to its peak between the seventh and ninth periods, and then begins to fade, vanishing completely by the 12th period.

Effect of Shock in Inflation, GDP Deflator (Annual %) LN_X3 on Itself:

A positive shock equivalent to one standard deviation in inflation (GDP deflator, annual %) will begin to have an impact in the middle of the first period. The effect decreases sharply until the middle of the second period, then gradually fades

with a decreasing slope until it vanishes completely by the 14th period.

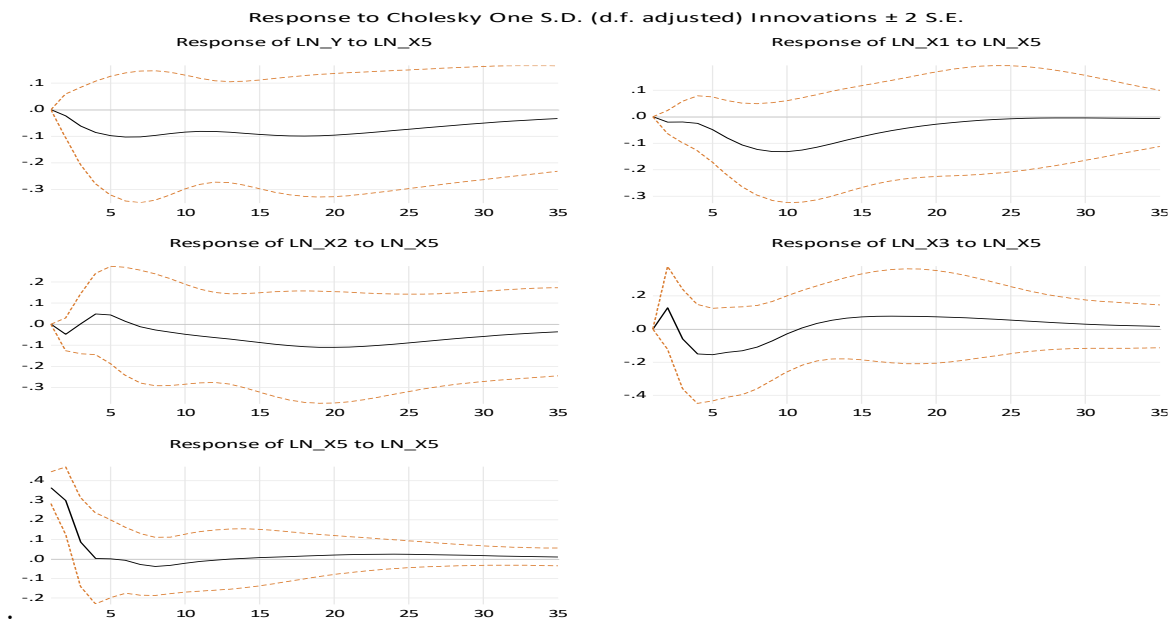
Effect of Shock in U.S. Inflation, GDP Deflator (Annual %) LN_X5 on Inflation, GDP Deflator (Annual %) LN_X3:

A positive shock equivalent to one standard deviation in U.S. inflation (GDP deflator, annual %) will lead to a positive shock in inflation (GDP deflator, annual %) in Egypt. The effect starts at the end of the second third of the first period, peaks in the first third of the second period, then begins to fade, vanishing completely by the sixth period.

Observation on Inflation Shocks (Local vs. Imported):

It is noted that the effects of imported (U.S.) inflation shocks on local inflation (GDP deflator, annual %) are similar to the effects of local inflation shocks on itself. However, local inflation shocks exhibit greater intensity and a longer-lasting impact compared to imported inflation shocks.

Figure (5): Analysis of the Impact of Shocks on the Variable LN_X5



Source: EVIEWS12 outputs based on World Bank data for the period 1977-2022, Available at: World Bank Indicator (Accessed on 1/10/2024).

Impact of Shocks on the Variable LN_X5

Effect of Shock in Exchange Rate LN_Y on U.S. Inflation, GDP Deflator (Annual %) LN_X5:

A positive shock equivalent to one standard deviation in the U.S. dollar exchange rate will lead to an inverse shock in the U.S. inflation (GDP deflator, annual %) LN_X5. The effect begins in the middle of the first period, increases gradually with a mild slope, and peaks at the end of the fifth period. It stabilizes until the tenth period, then gradually fades until it completely vanishes by the 45th period.

Effect of Shock in Total External Debt (Debt Outstanding and Disbursed, Current USD) LN_X1 in Egypt on U.S. Inflation, GDP Deflator (Annual %) LN_X5:

A positive shock equivalent to one standard deviation in Egypt's total external debt (debt outstanding and disbursed, current USD) will have a significant inverse impact on U.S. inflation (GDP deflator, annual %) LN_X5. The effect begins at the end of the first period, remains mild until the middle of the fifth period, then intensifies, peaking in the tenth period. The impact begins to decline thereafter and completely vanishes by the 21st period.

Effect of Shock in Total Reserves (Including Gold, Current USD) LN_X2 in Egypt on U.S. Inflation, GDP Deflator (Annual %) LN_X5:

A positive shock equivalent to one standard deviation in Egypt's total reserves (including gold and current USD) will have an inverse impact on U.S. inflation (GDP deflator, annual %). The effect begins in the last quarter of the first period, reaches its lowest point in the middle of the second period, and then fades, vanishing completely by the middle of the third period. The impact later switches to a

positive effect, peaking in the middle of the fourth period, stabilizing until the middle of the fifth period, and then gradually fading until it vanishes by the end of the fifth period.

Effect of Shock in Egypt's Inflation, GDP Deflator (Annual %) LN_X3 on U.S. Inflation, GDP Deflator (Annual %) LN_X5:

A positive shock equivalent to one standard deviation in Egypt's inflation (GDP deflator, annual %) will have a positive impact on U.S. inflation (GDP deflator, annual %). The effect begins in the last quarter of the first period, peak in the middle of the second period, and then fades, vanishing completely by the end of the second period. Subsequently, the impact turns negative, peaking in the middle of the fourth period, and gradually fades until it vanishes completely by the 11th period.

Effect of Shock in U.S. Inflation, GDP Deflator (Annual %) LN_X5 on Itself:

A positive shock equal to one standard deviation in U.S. inflation (GDP deflator, annual %) will have an immediate impact on the same variable, LN_X5. The effect begins in the middle of the first period, decreases with a mild slope until the middle of the second period, and then declines more sharply, completely vanishing by the middle of the fourth period.

Observation on the Flexibility of Inflation Control Tools in the U.S. vs. Egypt:

This reflects the flexibility and effectiveness of inflation-control tools in the United States compared with those in Egypt. This discrepancy can be attributed to the nature of imported goods in Egypt, which are primarily capital or technological goods with limited flexibility in responding to interest rate changes.

These goods often have no local substitutes and are essential for domestic production. Consequently, the limited effectiveness of inflation-control tools in Egypt weakens

the impact of exchange-rate depreciation in reducing the current account deficit, as prescribed by IMF policies.

5-3-2-6-2 Variance Decomposition

Table (11): Variance Decomposition of LN_Y

Period	SE	Variance Decomposition of LN_Y:				
		LN_Y	LN_X1	LN_X2	LN_X3	LN_X5
1	0.191213	100.0000	0.000000	0.000000	0.000000	0.000000
2	0.307872	97.85324	1.024550	0.146712	0.415600	0.559901
3	0.398967	93.54294	2.358561	0.629020	0.764282	2.705200
4	0.468602	88.90846	3.491954	1.287927	1.002810	5.308850
5	0.519896	85.13170	4.104280	1.827781	1.099376	7.836858
6	0.557223	82.32478	4.226781	2.161343	1.080767	10.20633
7	0.585084	80.28150	4.071325	2.345433	1.005806	12.29594
8	0.606977	78.80732	3.828470	2.458879	0.934651	13.97068
9	0.625395	77.71206	3.606291	2.558943	0.900105	15.22260
10	0.642046	76.80619	3.442797	2.684861	0.908524	16.15763
11	0.657970	75.93551	3.332152	2.865017	0.954847	16.91247
12	0.673688	74.99754	3.251211	3.113695	1.033853	17.60370
13	0.689384	73.93943	3.178991	3.424082	1.144222	18.31327
14	0.705044	72.75218	3.104056	3.768873	1.288137	19.08676
15	0.720540	71.46262	3.023309	4.110648	1.468854	19.93457
16	0.735685	70.12105	2.938282	4.415245	1.687790	20.83763
17	0.750277	68.78588	2.852109	4.660835	1.942303	21.75887
18	0.764128	67.51019	2.767834	4.840170	2.224971	22.65684
19	0.777087	66.33354	2.687772	4.957608	2.524533	23.49655
20	0.789053	65.27964	2.613462	5.024075	2.827929	24.25489
21	0.799969	64.35783	2.545842	5.052481	3.122607	24.92124
22	0.809822	63.56648	2.485429	5.054747	3.398326	25.49502
23	0.818629	62.89678	2.432418	5.040470	3.648109	25.98222
24	0.826433	62.33606	2.386720	5.016704	3.868332	26.39218
25	0.833292	61.87030	2.347986	4.988304	4.058213	26.73520
26	0.839276	61.48578	2.315639	4.958451	4.219020	27.02111
27	0.844463	61.16995	2.288940	4.929142	4.353279	27.25869
28	0.848932	60.91174	2.267064	4.901575	4.464113	27.45551
29	0.852763	60.70156	2.249186	4.876414	4.554789	27.61805
30	0.856035	60.53115	2.234541	4.853973	4.628437	27.75190
31	0.858823	60.39340	2.222468	4.834329	4.687910	27.86189
32	0.861194	60.28223	2.212418	4.817405	4.735731	27.95222
33	0.863212	60.19242	2.203957	4.803027	4.774081	28.02652
34	0.864930	60.11961	2.196751	4.790963	4.804816	28.08786
35	0.866397	60.06016	2.190546	4.780955	4.829494	28.13885
36	0.867653	60.01113	2.185153	4.772740	4.849402	28.18158
37	0.868733	59.97017	2.180429	4.766062	4.865588	28.21775
38	0.869666	59.93545	2.176268	4.760683	4.878889	28.24871
39	0.870475	59.90557	2.172585	4.756385	4.889963	28.27550
40	0.871181	59.87949	2.169317	4.752973	4.899323	28.29890

Source: EIEWS12 outputs based on World Bank data for the period 1977-2022, Available at: World Bank Indicator (Accessed on 1/10/2024).

The table shows that a shock to LN_Y causes a 100% change in LN_Y in the first period, with no effect on the other variables. Over time, the effect of the shock gradually decreases to 97.85% in the second year, 65.28% in the 20th period, and 59.88% in the 40th period.

As the impact on LN_Y decreases, its influence on other variables increases progressively. For instance:

- LN_X1: Impact starts at 1.025% in the second period and reaches 2.17% in the 40th period.

- LN_X5: Impact starts at 0.56% in the second period and reaches 28.3% in the 40th period.

- LN_X3: Impact starts at 0.42% in the second period and reaches 4.9% in the 40th period.

- LN_X2: Impact starts at 0.15% in the second period and reaches 4.75% in the 40th period.

A shock to LN_Y has the strongest effect on itself, and the impact on other variables varies over different periods. The shock exhibits a strong memory effect.

Table (12): Variance Decomposition of LN_X1

Period	SE	Variance Decomposition of LN_X1:				
		LN_Y	LN_X1	LN_X2	LN_X3	LN_X5
1	0.101180	0.300498	99.69950	0.000000	0.000000	0.000000
2	0.166192	0.115620	95.34815	1.863834	1.197158	1.475238
3	0.215647	0.761478	87.37896	7.579510	2.547873	1.732183
4	0.259235	2.661183	76.99374	14.62700	3.595185	2.122892
5	0.301175	4.747486	65.88310	20.69103	4.512290	4.166086
6	0.343330	6.159328	54.95689	24.69968	5.536886	8.647214
7	0.385206	6.826104	45.44874	26.44525	6.763502	14.51640
8	0.424867	7.041897	38.03818	26.36938	8.185712	20.36483
9	0.460780	7.074411	32.57476	25.17082	9.734560	25.44545
10	0.492138	7.086558	28.62303	23.50113	11.30690	29.48239
11	0.518599	7.164912	25.78700	21.81532	12.79215	32.44062
12	0.540222	7.344343	23.76419	20.35043	14.09575	34.44529
13	0.557429	7.623509	22.32985	19.18330	15.15669	35.70665
14	0.570841	7.978005	21.32076	18.30262	15.95546	36.44316
15	0.581117	8.372306	20.62039	17.66108	16.50958	36.83665
16	0.588866	8.769940	20.14451	17.20459	16.86051	37.02044
17	0.594616	9.141046	19.83022	16.88535	17.05898	37.08441
18	0.598815	9.466474	19.62940	16.66554	17.15349	37.08509
19	0.601828	9.738214	19.50533	16.51674	17.18389	37.05583
20	0.603953	9.957058	19.43074	16.41787	17.17920	37.01513
21	0.605426	10.12911	19.38626	16.35329	17.15853	36.97281
22	0.606432	10.26259	19.35900	16.31146	17.13317	36.93379
23	0.607114	10.36568	19.34096	16.28402	17.10906	36.90028
24	0.607575	10.44544	19.32767	16.26526	17.08872	36.87291
25	0.607891	10.50749	19.31685	16.25158	17.07272	36.85135
26	0.608112	10.55613	19.30751	16.24096	17.06062	36.83477
27	0.608274	10.59455	19.29926	16.23250	17.05154	36.82215
28	0.608400	10.62515	19.29194	16.22584	17.04453	36.81254
29	0.608504	10.64973	19.28545	16.22085	17.03876	36.80522
30	0.608596	10.66967	19.27962	16.21739	17.03363	36.79970
31	0.608683	10.68602	19.27428	16.21520	17.02879	36.79571
32	0.608768	10.69962	19.26922	16.21396	17.02410	36.79310
33	0.608853	10.71110	19.26428	16.21329	17.01958	36.79176
34	0.608941	10.72095	19.25931	16.21283	17.01534	36.79157
35	0.609031	10.72957	19.25422	16.21230	17.01151	36.79240

Period	SE	Variance Decomposition of LN_X1:				
		LN_Y	LN_X1	LN_X2	LN_X3	LN_X5
36	0.609122	10.73725	19.24901	16.21150	17.00818	36.79406
37	0.609213	10.74419	19.24369	16.21035	17.00540	36.79637
38	0.609303	10.75055	19.23834	16.20881	17.00319	36.79912
39	0.609391	10.75645	19.23303	16.20692	17.00149	36.80212
40	0.609475	10.76194	19.22787	16.20475	17.00024	36.80520

Source: *EIEWS12 outputs based on World Bank data for the period 1977-2022, Available at: World Bank Indicator (Accessed on 1/10/2024).*

The table shows that a shock to LN_X1 causes a 99.7% change in LN_X1 and a 0.3% change in LN_Y in the first period, with no effect on the other variables. Over time, the effect of the shock on LN_X1 gradually decreases to 95.35% in the second year and to 19.22% in the 40th period.

As the impact on LN_X1 decreases, its influence on other variables increases progressively. For instance:

- LN_Y: Impact starts at 0.12% in the second period and reaches 10.76% in the 40th period.

- LN_X2: Impact starts at 1.86% in the second period and reaches 16.2% in the 40th period.

- LN_X3: Impact starts at 1.2% in the second period and reaches 17% in the 40th period.

- LN_X5: Impact starts at 1.48% in the second period and reaches 36.8% in the 40th period.

A shock to LN_X1 has the strongest effect on itself, and the impact on other variables varies over different periods. The shock exhibits a strong memory effect.

Table (13): Variance Decomposition Analysis for a Shock in the Variable LN_X2

Period	SE	Variance Decomposition of LN_X2:				
		LN_Y	LN_X1	LN_X2	LN_X3	LN_X5
1	0.178685	22.10048	0.069949	77.82957	0.000000	0.000000
2	0.303209	40.30098	0.566615	56.51628	0.107052	2.509070
3	0.401512	54.68458	3.356959	40.27844	0.247828	1.432191
4	0.488075	62.21924	5.193815	29.25279	1.402635	1.931522
5	0.554318	65.88104	5.720963	23.03997	3.252565	2.105468
6	0.600170	67.60402	5.792867	19.65496	5.105561	1.842600
7	0.631739	68.16885	5.696626	17.87124	6.562374	1.700906
8	0.653803	68.21408	5.483908	17.02407	7.514603	1.763343
9	0.669833	68.07749	5.238431	16.68034	7.996941	2.006793
10	0.682683	67.82039	5.061414	16.58317	8.108684	2.426335
11	0.694419	67.41803	4.994360	16.60460	7.980787	3.002228
12	0.706289	66.85154	5.016338	16.68498	7.737159	3.709983
13	0.718955	66.11256	5.078682	16.79175	7.468858	4.548154
14	0.732689	65.20090	5.132660	16.90024	7.233079	5.533129
15	0.747472	64.13180	5.145453	16.98612	7.062544	6.674087
16	0.763079	62.94022	5.105494	17.02487	6.973381	7.956034
17	0.779159	61.67683	5.018121	16.99669	6.969622	9.338734
18	0.795304	60.39926	4.897162	16.89253	7.045858	10.76519
19	0.811111	59.16286	4.757970	16.71656	7.189420	12.17319
20	0.826223	58.01333	4.613667	16.48373	7.382741	13.50653
21	0.840361	56.98230	4.473858	16.21448	7.606075	14.72329

Period	SE	LN_Y	LN_X1	LN_X2	LN_X3	LN_X5
22	0.853332	56.08633	4.344706	15.92962	7.840262	15.79908
23	0.865029	55.32881	4.229588	15.64674	8.068982	16.72588
24	0.875422	54.70328	4.129844	15.37866	8.280127	17.50808
25	0.884537	54.19704	4.045421	15.13340	8.466177	18.15796
26	0.892440	53.79429	3.975356	14.91490	8.623782	18.69167
27	0.899225	53.47849	3.918135	14.72418	8.752854	19.12634
28	0.905002	53.23394	3.871964	14.56027	8.855507	19.47832
29	0.909886	53.04661	3.834983	14.42110	8.935077	19.76223
30	0.913992	52.90453	3.805421	14.30402	8.995353	19.99068
31	0.917428	52.79773	3.781703	14.20619	9.040058	20.17432
32	0.920298	52.71809	3.762503	14.12485	9.072556	20.32200
33	0.922692	52.65906	3.746759	14.05743	9.095716	20.44103
34	0.924691	52.61543	3.733655	14.00164	9.111890	20.53738
35	0.926365	52.58308	3.722579	13.95548	9.122947	20.61592
36	0.927773	52.55882	3.713090	13.91723	9.130340	20.68052
37	0.928964	52.54023	3.704864	13.88548	9.135171	20.73426
38	0.929979	52.52547	3.697672	13.85903	9.138263	20.77956
39	0.930849	52.51325	3.691342	13.83691	9.140220	20.81828
40	0.931602	52.50264	3.685743	13.81832	9.141473	20.85182

Source: EVIEWS12 outputs based on World Bank data for the period 1977-2022, Available at: World Bank Indicator (Accessed on 1/10/2024).

From the table above, it is evident that a shock to LN_X2 results in a 77.83% change in LN_X2 itself, a 22.1% change in LN_Y, and a 0.07% change in LN_X1, with no effect on the remaining variables during the first period. The impact of the shock gradually diminishes on LN_X2, reaching 56.52% in the second year and declining to 13.82% by the 40th period.

As the shock's impact on LN_X2 diminishes, its influence on other variables gradually increases. For instance, its impact on LN_Y doubles, starting at 40.3% in the second period, peaking at 68.08% in the ninth period, and then gradually decreasing to 52.5% in the 40th period.

The shock's impact on LN_X1 starts at 0.57% in the second period, increasing to 5.06% in the 10th period, and then fluctuates, settling at 3.69% in the 40th period. Its impact on LN_X3 begins at 0.11% in the second period, rising to 8.11% in the 10th period and continuing to rise, albeit with fluctuations, reaching 9.14% in the 40th period. Similarly, the shock's effect on LN_X5 begins at 2.5% in the second period and gradually increases to 9.14% in the 40th period.

The results show that a shock to LN_X2 has the strongest effect on itself, with varying impacts on other variables across periods. The shock exhibits strong memory characteristics.

Table (14): Variance Decomposition Analysis for a Shock in the Variable LN_X3

Period	SE	Variance Decomposition of LN_X3:				
		LN_Y	LN_X1	LN_X2	LN_X3	LN_X5
1	0.576883	11.57326	0.001613	4.611817	83.81331	0.000000
2	0.664009	17.21033	1.102631	3.541417	74.39981	3.745808
3	0.705264	18.80934	1.856964	3.301588	72.00134	4.030773
4	0.742088	17.81491	1.680615	4.262295	68.49018	7.751999
5	0.774621	16.40091	1.844836	5.317314	65.34252	11.09442
6	0.799498	15.45400	2.181361	5.547791	63.29748	13.51937
7	0.820012	14.98263	2.435952	5.306415	61.87868	15.39632

Period	SE	LN Y	LN X1	LN X2	LN X3	LN X5
8	0.836996	14.83244	2.635857	5.178146	60.88056	16.47300
9	0.849690	14.83201	2.821989	5.422180	60.23191	16.69191
10	0.858932	14.84654	2.991469	6.019881	59.68954	16.45257
11	0.866272	14.82068	3.138946	6.803524	59.05607	16.18078
12	0.872773	14.75646	3.270466	7.579296	58.30194	16.09184
13	0.879028	14.67195	3.390172	8.220369	57.48622	16.23129
14	0.885356	14.58532	3.493612	8.686537	56.67829	16.55624
15	0.891855	14.51460	3.572388	8.993500	55.92734	16.99218
16	0.898478	14.47554	3.620698	9.177417	55.25425	17.47209
17	0.905117	14.47687	3.638115	9.274277	54.65734	17.95340
18	0.911646	14.51798	3.629234	9.312426	54.12525	18.41511
19	0.917933	14.59075	3.601869	9.311890	53.64745	18.84804
20	0.923850	14.68365	3.564696	9.286203	53.21799	19.24746
21	0.929292	14.78571	3.525172	9.244669	52.83485	19.60960
22	0.934180	14.88880	3.488420	9.194150	52.49769	19.93094
23	0.938472	14.98818	3.457146	9.140064	52.20589	20.20872
24	0.942159	15.08183	3.432174	9.086702	51.95746	20.44184
25	0.945264	15.16925	3.413154	9.037193	51.74886	20.63155
26	0.947836	15.25055	3.399165	8.993450	51.57544	20.78139
27	0.949935	15.32586	3.389120	8.956263	51.43209	20.89666
28	0.951630	15.39513	3.381998	8.925546	51.31387	20.98345
29	0.952988	15.45816	3.376936	8.900670	51.21637	21.04786
30	0.954072	15.51476	3.373257	8.880762	51.13587	21.09535
31	0.954935	15.56485	3.370463	8.864924	51.06930	21.13047
32	0.955625	15.60857	3.368204	8.852349	51.01415	21.15673
33	0.956178	15.64624	3.366257	8.842368	50.96837	21.17676
34	0.956626	15.67840	3.364489	8.834447	50.93023	21.19244
35	0.956993	15.70565	3.362837	8.828163	50.89828	21.20507
36	0.957296	15.72867	3.361280	8.823184	50.87132	21.21555
37	0.957552	15.74807	3.359816	8.819246	50.84836	21.22450
38	0.957770	15.76446	3.358454	8.816135	50.82859	21.23235
39	0.957960	15.77835	3.357199	8.813680	50.81138	21.23940
40	0.958127	15.79015	3.356054	8.811738	50.79622	21.24583

Source: EViews12 outputs based on World Bank data for the period 1977-2022, Available at: World Bank Indicator (Accessed on 1/10/2024).

From the above table, it is evident that a shock in LN_X3 impacts 83.81% of the variable itself, 11.57% of LN_Y, 4.61% of LN_X2, and 0.002% of LN_X1, with no effect on LN_X5 during the first period. The impact of the shock on LN_X3 gradually decreases, albeit slowly, reaching 74.4% in the second year and continuing to decrease to 50.8% by the 40th period.

As the impact of the shock on LN_X3 decreases, its influence on other variables increases. For example, the effect on LN_Y increases to 17.21% in the second period and 18.8% in the third

period, then fluctuates, reaching 15.79% in the 40th period.

The shock's impact on LN_X1 increases from 1.1% in the second period to 3.36% in the 40th period, while its influence on LN_X2 rises to 8.81% in the 40th period. The shock's effect on LN_X5 starts at 3.75% in the second period, eventually reaching 21.24% in the 40th period.

The results indicate that a shock in LN_X3 has the strongest effect on itself, with varying impacts on other variables depending on the period. The shock exhibits strong memory characteristics.

Table (15): Variance Decomposition Analysis for Shock in Variable LN_X5

Period	SE	Variance Decomposition of LN_X5:				
		LN_Y	LN_X1	LN_X2	LN_X3	LN_X5
1	0.368291	1.109696	0.844763	0.000475	0.153577	97.89149
2	0.488455	1.248994	3.297533	0.004555	2.390155	93.05876
3	0.511003	1.145756	6.626925	0.438828	3.925498	87.86299
4	0.523351	1.555866	7.203993	2.959537	4.512621	83.76798
5	0.535331	2.376178	7.025336	5.958317	4.579323	80.06084
6	0.544249	3.446392	6.932488	7.674363	4.470985	77.47577
7	0.551378	4.629315	6.953714	8.297597	4.373505	75.74587
8	0.557665	5.675342	6.958662	8.396123	4.446139	74.52373
9	0.562359	6.416563	6.933169	8.318634	4.703279	73.62836
10	0.565450	6.855803	6.903418	8.228730	5.036693	72.97536
11	0.567451	7.085328	6.873588	8.185743	5.343422	72.51192
12	0.568747	7.198906	6.844914	8.189420	5.572879	72.19388
13	0.569594	7.258286	6.825981	8.220205	5.715980	71.97955
14	0.570204	7.296092	6.824102	8.263262	5.787529	71.82901
15	0.570730	7.328155	6.838667	8.311785	5.811405	71.70999
16	0.571271	7.362532	6.863251	8.363344	5.809601	71.60127
17	0.571881	7.403219	6.889772	8.416906	5.797636	71.49247
18	0.572590	7.451118	6.911301	8.471221	5.784956	71.38140
19	0.573401	7.504742	6.923634	8.524021	5.776897	71.27071
20	0.574306	7.561378	6.925622	8.572043	5.776313	71.16464
21	0.575280	7.618316	6.918413	8.611870	5.784474	71.06693
22	0.576291	7.673643	6.904306	8.641044	5.801460	70.97955
23	0.577306	7.726481	6.885854	8.658766	5.826321	70.90258
24	0.578292	7.776763	6.865335	8.665921	5.857253	70.83473
25	0.579223	7.824822	6.844541	8.664562	5.891886	70.77419
26	0.580078	7.871008	6.824735	8.657231	5.927681	70.71935
27	0.580847	7.915469	6.806710	8.646362	5.962331	70.66913
28	0.581525	7.958084	6.790884	8.633938	5.994056	70.62304
29	0.582112	7.998520	6.777392	8.621369	6.021739	70.58098
30	0.582614	8.036346	6.766167	8.609538	6.044907	70.54304
31	0.583037	8.071161	6.757010	8.598914	6.063608	70.50931
32	0.583390	8.102678	6.749648	8.589678	6.078239	70.47976
33	0.583683	8.130777	6.743780	8.581833	6.089383	70.45423
34	0.583923	8.155499	6.739114	8.575280	6.097678	70.43243
35	0.584120	8.177019	6.735388	8.569872	6.103735	70.41398
36	0.584281	8.195603	6.732383	8.565447	6.108087	70.39848
37	0.584412	8.211562	6.729926	8.561845	6.111173	70.38549
38	0.584519	8.225221	6.727884	8.558924	6.113341	70.37463
39	0.584608	8.236888	6.726161	8.556559	6.114856	70.36554
40	0.584681	8.246850	6.724686	8.554649	6.115917	70.35790

Cholesky Ordering: LN_Y LN_X1 LN_X2 LN_X3 LN_X5

Source: EIEWS12 outputs based on World Bank data for the period 1977-2022, Available at: World Bank Indicator (Accessed on 1/10/2024).

From the table above, it is clear that a shock to the variable **LN_X5** distributes its impact as follows: 97.89% on the variable itself, 1.11% on the variable **LN_Y**, 0.84% on the variable **LN_X1**, 0.0004% on the variable **LN_X2**, and

0.15% on the variable **LN_X3** in the first period. The impact of the shock gradually diminishes on **LN_X5**, albeit slowly, reaching 93.06% in the second year and declining to 70.36% in the fortieth period.

As the shock's impact on **LN_X5** decreases, its effect on the other variables gradually increases. The effect on **LN_Y** rises to 1.25% in the second period, eventually increasing to 8.25% in the fortieth period.

The impact on **LN_X1** increases to 3.3% in the second period, reaching 7.2% in the fourth period, and then fluctuates, albeit very slowly, until it reaches 6.72% in the fortieth period.

The shock's impact on **LN_X2** increases to 8.6% in the fortieth period, while its impact on **LN_X3** rises by 2.39% in the second period and reaches 6.12% in the fortieth period.

When a shock occurs in the variable **LN_X5**, its impact is strongest on the variable itself, while its effect on the other variables varies across periods. The shock demonstrates strong memory retention.

5-3-2-6-3 Summary of Shock Analysis:

It is noted from the previous analysis:

- The shocks occurring in exchange rates or their determinants have strong memory, meaning they dissipate slowly.
- The impact of any shock in the determinants has a greater effect on the exchange rate than the effect of these determinants on each other.
- The slow dissipation of shocks reflects the rigidity of the tools for controlling the exchange rate or the tools influencing its determinants. This is due to the nature of demand for Egyptian imports, which is characterized by low elasticity. This raises questions about the effectiveness of using exchange rate depreciation to address the current account deficit and balance of payments.

- The strongest impact of shocks on the exchange rate is:

- Shocks occurring in the variable itself, followed by shocks in **LN_X2**, followed by shocks in **LN_X3**, followed by shocks in **LN_X5**, and finally shocks in **LN_X1**.

- The strongest impact of shocks on **LN_X1** is:

- Shocks occurring in the variable itself, followed by shocks in **LN_Y**, followed by shocks in **LN_X5**, followed by shocks in **LN_X2**, and finally shocks in **LN_X3**.

- The strongest impact of shocks on **LN_X2** is:

- Shocks occurring in the variable itself, followed by shocks in **LN_X3**, followed by shocks in **LN_X1**, followed by shocks in **LN_Y**, and finally shocks in **LN_X5**.

- The strongest impact of shocks on **LN_X3** is:

- Shocks occurring in the variable itself, followed by shocks in **LN_X1**, followed by shocks in **LN_Y**, followed by shocks in **LN_X5**, and finally shocks in **LN_X2**.

- The strongest impact of shocks on **LN_X5** is:

- Shocks occurring in the variable itself, followed by shocks in **LN_X3**, followed by shocks in **LN_X2**, followed by shocks in **LN_X1**, and finally shocks in **LN_Y**.

6- Results and Recommendations

6-1 Results:

1- According to the analysis of Impulse Response Functions:

- Shocks in domestic inflation (LN_X3) are more harmful to the exchange rate (LN_Y) and have a longer memory in dissipation compared to imported inflation (LN_X5).

- Shocks in imported inflation (American) (LN_X5) have a greater impact on Egypt's external debt balance than domestic inflation (LN_X3).

- The impact of shocks in imported inflation (American) (LN_X5) is similar to that of shocks in domestic inflation (LN_X3) on total reserves (including gold, at current US dollar prices), but American inflation has a stronger memory in dissipation.

- The impact of shocks in American imported inflation (LN_X5) on domestic inflation (LN_X3) is comparable to the impact of shocks in domestic inflation (LN_X3) on itself, but the impact of domestic inflation is more intense.

2- Shocks in the exchange rate (LN_Y) have strong memory and dissipate slowly.

3- Shocks in the determinants of the exchange rate (LN_X(i)) have strong memory and dissipate slowly.

4- The strongest impact of shocks on the exchange rate (LN_Y) comes from shocks occurring in the variable itself, followed by shocks in its determinants in the following order:

- Total reserves (including gold, at current US dollar prices) (LN_X2),

- Inflation (GDP deflator, % annual) (LN_X3),

- American imported inflation (LN_X5),

- Total external debt balance (outstanding and disbursed, at current US dollar prices) (LN_X1).

5- The strongest impact of shocks on the total external debt balance (outstanding and disbursed, at current US dollar prices) (LN_X1) comes from shocks occurring in the variable itself, followed by:

- Official exchange rate (local currency per US dollar, period average) (LN_Y),

- American imported inflation (LN_X5),

- Total reserves (including gold, at current US dollar prices) (LN_X2),

- Inflation (GDP deflator, % annual) (LN_X3).

6- The strongest impact of shocks on total reserves (including gold, at current US dollar prices) (LN_X2) comes from shocks occurring in the variable itself, followed by:

- Inflation (GDP deflator, % annual) (LN_X3),

- Total external debt balance (outstanding and disbursed, at current US dollar prices) (LN_X1),

- Official exchange rate (local currency per US dollar, period average) (LN_Y),

- American imported inflation (LN_X5).

7- The strongest impact of shocks on LN_X3 comes from shocks occurring in the variable itself, followed by:

- Total external debt balance (outstanding and disbursed, at current US dollar prices) (LN_X1),
- LN_Y,
- American imported inflation (LN_X5),
- Total reserves (including gold, at current US dollar prices) (LN_X2).

8- The strongest impact of shocks on LN_X5 comes from shocks occurring in the variable itself, followed by:

- Inflation (GDP deflator, % annual) (LN_X3),
- Total reserves (including gold, at current US dollar prices) (LN_X2),
- Total external debt balance (outstanding and disbursed, at current US dollar prices) (LN_X1),
- Official exchange rate (local currency per US dollar, period average) (LN_Y).

6-2 Recommendations and Future Studies:

6-2-1 Recommendations:

- 1. Reduce reliance on external debt:**
The study found a strong positive correlation between total external debt and the EGP exchange rate. It is crucial to limit external borrowing unless tied to productive plans that generate stable dollar revenues.
- 2. Enhance international reserves sustainably:**
Given the reserves' positive impact on exchange rate stability, diversify reserve sources (tourism, exports, remittances) instead of relying on borrowing to boost reserves.

3. Implement policies to control domestic and global inflation:

The results showed that U.S. inflation affects Egypt's economic variables more than domestic inflation does. Proactive policies are needed to mitigate the effects of global inflation.

4. Encourage domestic investment:

Total capital formation has an inverse effect on the dollar exchange rate (strengthening the EGP). Incentivize local investment to improve monetary stability and reduce currency pressure.

5. Develop proactive tools to manage external shocks:

External shocks (global crises, wars, oil prices) have the most significant impact. The Central Bank and the Ministry of Finance should design hedging mechanisms (such as strategic reserves and trade partner diversification) to minimize the effects.

6-2-2: Future Studies:

- 1. Study the cumulative impact of dual shocks (domestic + external) on the exchange rate:**
Current research has focused on isolated shocks, but overlapping shocks may have compounding effects that warrant assessment.
- 2. Dynamic analysis of shock impacts on Egypt's balance of payments using SVAR models:**
To understand how shocks affect the current account, investments, and remittances, and their spillover effects on the exchange rate.
- 3. Analyze the impact of local banking sector shocks (e.g., sudden interest rate hikes) on the exchange rate:**

Particularly during crises, to assess influence the extent to which abrupt monetary policy influences exchange rate movements.

4. Study the effect of regional geopolitical shocks (e.g., Arab crises, Eastern Mediterranean tensions) on the EGP:

Use monthly/quarterly data to measure the speed of shock transmission compared to global crises.

5. Test machine learning models to predict shock impacts on the EGP:

Compare traditional VAR models with advanced models (LSTM, Random Forest) in forecasting exchange rate volatility under shocks.

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DOI: 10.33948/ESJ-KSU-18-1-6

تقييم تأثير الصدمات الاقتصادية على سعر صرف الجنيه المصري خلال الفترة 1977-2022

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(قُدِّم للنشر: 03 مارس، 2025م - وقُبِل للنشر: 02 يوليو، 2025م)

المستخلص:

يدرس هذا البحث كيفية تأثير الصدمات الاقتصادية على سعر صرف الجنيه المصري (1977-2022)، مع التركيز على الديون الخارجية والاحتياطيات الأجنبية ومعدلات التضخم. باستخدام نماذج VAR وبيانات البنك الدولي، توصلت النتائج إلى: تتمتع الصدمات التي تتعرض لها سعر الصرف ومحدداته (الاحتياطيات، التضخم، الديون) بآثار ممتدة تُضعف تدريجياً بمرور الوقت. يُظهر سعر الصرف حساسية أكبر تجاه الصدمات الذاتية (الداخلية)، يليها الصدمات في الاحتياطيات (التأثير الخارجي الأبرز)، ثم صدمات التضخم المحلي، فالتضخم المستورد، وأخيراً صدمات الديون الخارجية. تكون صدمات التضخم المحلي أكثر تدميراً واستمرارية مقارنةً بصدمات التضخم المستورد. توصي الدراسة بتبني سياسات نقدية مستقرة للحد من التضخم، وتقليل الاعتماد على الديون الخارجية، وتعزيز الاحتياطيات الأجنبية لتعزيز الصمود أمام الصدمات. كما تُؤكد على ضرورة إجراء إصلاحات هيكلية لتحقيق استقرار سعر الصرف في ظل التحديات الاقتصادية.

الكلمات المفتاحية: سعر الصرف، الجنيه المصري، الصدمات الاقتصادية، التضخم المحلي، التضخم المستورد، الديون الخارجية، الاحتياطيات الأجنبية.