Foreign Direct Investment and industry value-added in Egypt: Economic complexity threshold analysis

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Abstract:

This research delves into the complex relationship between FDI and industrial value-added in Egypt, focusing on economic complexity as a critical factor. Using data from 1998 to 2021 and advanced econometric techniques, including threshold regression analysis, we uncover the non-linear dynamics of FDI's impact on Egypt's industrial sector. Our results challenge traditional linear models, revealing that FDI's influence on industrial value-added is not straightforward. We also find that control variables like human development, trade openness, economic growth, and political stability have significant positive effects on industrial value-added, in line with established economic theories. Importantly, we introduce economic complexity as a pivotal factor shaping this relationship. We use three dimensions of economic complexity -exports, technology, and research- as threshold indicators. Each dimension has a unique threshold value, highlighting the importance of fostering economic complexity in various aspects to attract FDI and promote industrial development. Specifically, our study identifies a U-shaped relationship between FDI and industrial value-added, where FDI has a negative impact when economic complexity is below a certain threshold but becomes positive as complexity exceeds it. This underscores the necessity of policies that promote economic diversification and sophistication. Furthermore, our research underscores the significance of technology and research-based economic complexity. As technological and research capabilities grow, attracting FDI depends on local capacity building rather than simple technology transfer. In conclusion, our research offers valuable insights for policymakers, emphasizing the importance of strategically promoting FDI in alignment with a country's economic complexity. This implies the need to invest in human capital, enhance economic complexity, and implement adaptable policies that respond to evolving complexity landscapes. These findings provide a strong foundation for addressing the challenges of industrial development in our increasingly interconnected global economy.

Keywords: FDI, Industry value-added, technological change, Economic Complexity, threshold regression analysis.

Jel Classification: F21, O14, O47, C22

1 Introduction:

Foreign direct investment FDI is among the most important economic drivers impacting national economies across all sectors. The industry sector is regarded as one of the key economic sectors supporting growth. However, the industry sector in Egypt has not achieved its potential, as the average contribution of the industry sector to the economic growth rate from 2020 until 2023 has reached around 31.7%.

FDI is one of the important factors with multiple dimensions. It contributes to achieving sustainable development goals (SDGs) and can be used to address the balance of payments deficit if properly planned. It also supports technological advancement in the industry by adopting advanced operating and management systems. On the other hand, countries face intense competition in attracting direct and indirect foreign investments, and various methods are employed to attract such investments. The significance of the study at a theoretical level lies in exploring the effects of FDI on the industry sector, which is one of the leading sectors in promoting economic growth and achieving optimal targets for enhancement. Meanwhile, the focus is on the practical aspects of measuring these effects and analyzing their results to build economic policies that can achieve targets that meet the economic aspirations of the Egyptian economy and help increase economic growth rates.

To achieve the study's goal, we applied a threshold regression methodology to assess the relationship in both the short and long run, taking into account the distinctive characteristics of the Egyptian economy and other factors that affect the relationship as controlling variables.

The study aims to make a scientific contribution to the existing literature through a deeper analysis of the nature of the relationship, considering the characteristics of the Egyptian economy, unlike the generalization faced by other literature that does not consider the distinctive characteristics of the economies, which could affect the effectiveness of their results. The study seeks to generate policy-oriented recommendations based on documented knowledge and standard analysis, through which economic growth supported by the development of the value added to the industry sector can be increased through FDI funds.

2 Literature Review:

Many countries, especially developing ones, suffer from a lack of financing due to the inability of domestic savings to meet the necessary needs for development. Developed and emerging economies also seek to attract more foreign direct investment to affect their growth rates significantly. Despite this, the controversy regarding economic importance is still raging at the level of empirical literature.

On the one hand, several literatures (Bajo-Rubio, 2022; Bournakis & Tsionas, 2022; Mamba et al., 2020; Ning et al., 2023) emphasized the importance of FDI in increasing productivity rates and supporting economic growth, especially in developing countries. This positive impact may occur through several channels, such as

the contribution of foreign direct investment in supporting technological progress in the host countries, improving productivity in local companies, improving workers' skills, and increasing the added value, especially in high-tech industries. In addition, FDI has helped the host countries to be more competitive in the global markets, which in turn helped improve exports and added value. In a related context, the impact of foreign direct investment on the industry sector was of greater importance than other sectors, especially in the light of directing these investments toward promising industries within the economy.

On the other hand, other literature has shown that vigorous efforts to attract FDI flows towards attracting FDI flows must be more cautious, especially in the light of ensuring the negative flows of these investments on the economies of the host countries (Hong et al., 2021; Oduola et al., 2022; Wang & Liu, 2023). Also (Abdouli & Hammami, 2020; Nasim et al., 2023) confirmed the extension of these negative effects to the environment, indirectly affecting the economy. In some cases, it has negatively affected the competitiveness of local companies, which led to their exit from the market or the reduction of employment due to the shift towards intensive-capital production.

At the level of the industry sector, the prominent study (Wen, 2007) concluded several important explanatory results at the time regarding the regional effects of FDI flows and its contribution to support industry sector exports, which subsequently contributed to the growth of regional income as well as the increase in gross domestic product. Many subsequent studies confirmed these results (Qiong & Minyu, 2013; Storm, 2015), including the pivotal role of FDI in bringing static and dynamic structural changes. While some other literature indicated that there are conflicting results regarding its impact on the industry sector and economic growth, and this is what calls for countries to adopt selective policies regarding foreign direct investments (Wako, 2021) at the same level (Wang & Liu, 2023) emphasized that innovation and development In the service sector, it was affected adversely because these investments were directed to the service sector. Despite that, it had an important role in supporting human capital, providing Internet services, and government support that can mitigate the consequences of these bad effects.

Among the important observations in the literature review is the negative relationship trend regarding developing countries, observed in several studies conducted on African countries, as in the case of sub-Saharan African countries (Appiah et al., 2023). (Kimiagari et al., 2023) also attributed this influence to the importance of the geographical location and infrastructure, the legislative framework, and the level of democracy. (Shah et al., 2023) confirmed the same results at the level of OECD countries and the contribution of foreign direct investment to achieving unfavorable growth. At the level of Latin American countries (Moralles & Moreno, 2020) determined the necessary threshold for local companies that achieve a positive and significant impact of FDI on economic growth in the economies of Latin American countries. The results differed greatly at the level of European countries according to the nature of the internal economies. At the level of the Visegrad group

(Hassan, 2022) emphasized that political and economic risk significantly impacts the volume of incoming foreign direct investments, and this supports the guidance by supporting the social, political, and economic structures of economies to attract more foreign direct investment. (Vasa & Angeloska, 2020) concluded that the impact of foreign direct investments on Serbia was weak in reducing the unemployment rate as well as in its impact on the rate of economic growth, despite the existence of a strong correlation between the growth of the industry sector and foreign direct investment flows, and in the same context it was concluded by (Josifidis & Supic, 2023) as they indicate that the impact of foreign direct investment on employment in some European countries is negative on employment, especially in sectors with higher added value. It was also confirmed by (Magazzino & Mele, 2022), who concluded that foreign direct investments do not affect economic growth in Malta by using the Artificial Neural Networks (ANNs) algorithm to predict the size of investments affecting growth. In addition, it was noted that the pivotal role of government intervention in its impact on the nature of the relationship, as (Du et al., 2014) emphasized the pivotal role of government aid in providing an attractive environment for foreign direct investment, which promoted productivity growth in the industry sector. This was later supported by (Lee et al., 2023; Nam et al., 2023), whether at the total or partial level, as well as the role of these investments in increasing the industry complexity of the country and improving technological development in addition to that, government requirements contributed at the environmental level or in providing a minimum level of human skills in supporting the long-term positive impact of FDI on economic growth (Guo et al., 2023), and this can be understood in light of the results of the study (Morita & Nguyen, 2021) that used the Subgame Perfect Nash model. Equilibria (SPNE), the pioneer, emphasized that companies pursue different strategies in technology transfer and their comparison between the cases of external returns that they will obtain and the level of transferred technology, as well as the results of the study (Li et al., 2021), which emphasized the importance of foreign direct investment in influencing value chains And that the investments directed to the high-technology industries had the greatest impact compared to the low- and medium-technology industries (LMT).

At the level of the Egyptian economy, the relationship was examined through several studies (Attia, 2016; Elshal, 2023; Khair, 2022), and despite the agreement of these studies on the direct and indirect effects of foreign direct investments, as in the study (Salem & Younis, 2021). Furthermore, those investments are affected by political and economic risks more than financial risks. Their negative impact on the environmental aspect (Abdouli & Hammami, 2020) as well as factors repelling those investments such as (Ezz, 2018), but until now, the direct impact of foreign direct investments has not been studied On the industry sector in particular and the channels that transmit this effect as well. There was no clear line of proposed measures to enhance the benefit of these investments.

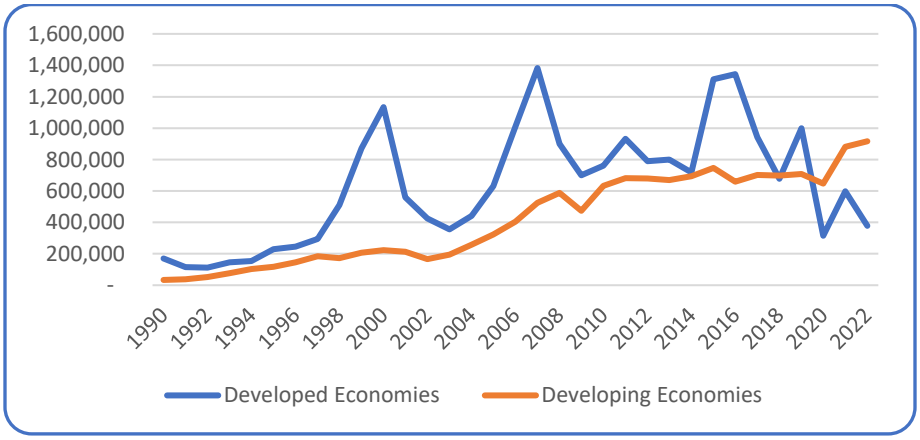
From this, the importance of examining the impact of FDI on the industry sector, in particular, is clear because of its importance compared to other sectors and the continuing conflicting results regarding the effects of FDI on the economic situation of the state, whether directly or indirectly, taking into account the characteristics of the economy that play a role Important in determining the nature of this relationship and determining the channels that convey this influence according to the nature of the economy. This enables policymakers to define the state's role in this context in a way that maximizes foreign direct investment returns in the short and long term.

3 FDI inflows-industry sector: Exploring dynamics in Egypt:

According to UNCTAD, Egypt is the biggest beneficiary of foreign direct investment in Africa and among the top FDI countries in the Middle East in 2021. Egypt's economy is remarkably stable and adaptable. Since the start of serious economic changes in 2016, the country's economy and population have been expanding and strengthening. Despite the difficulties, the government is dedicated to the 2030 national agenda and (SDGs), creating a climate attractive to foreign investors and fast-growing businesses.

Several metrics will be utilized to analyze the industry sector in Egypt, including economic complexity and Network Readiness Index. The economic complexity index ECI measures the diversity and sophistication of o a country's exports. This measure considers the diversity of products that the country exports and the complexity of those products.

Figure 1: Total foreign direct investments flow, worldwide.

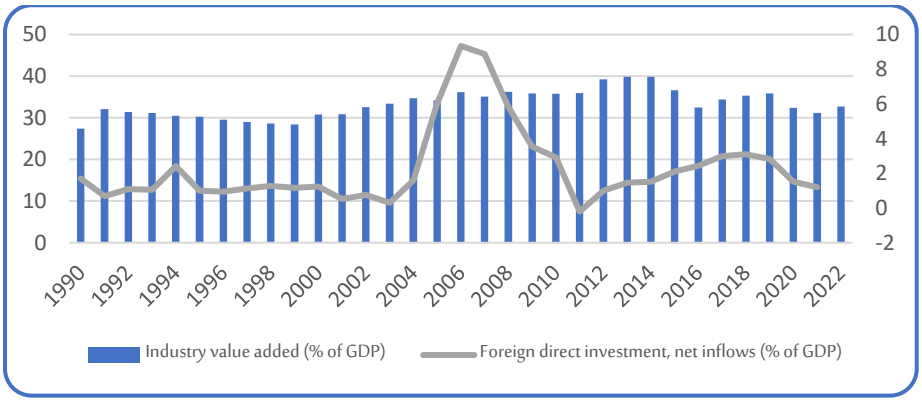


Source: based on (UNCTAD, 2023), available at: https://bit.ly/3YujnUO

The data in **figure 1** shows a clear dominance of developed countries in acquiring foreign direct investment flows compared to developing countries; this gap peaked during three main periods in 2000, 2007, and 2016. This may be due to economic stability, skilled labor, legal protection (Amuka, 2017; Belgibayeva & Plekhanov, 2019), and state wealth (Rodríguez-Pose & Cols, 2017). However, this relationship altered its direction by 2020, possibly due to the Corona pandemic's global consequences(Chattopadhyay et al., 2022).

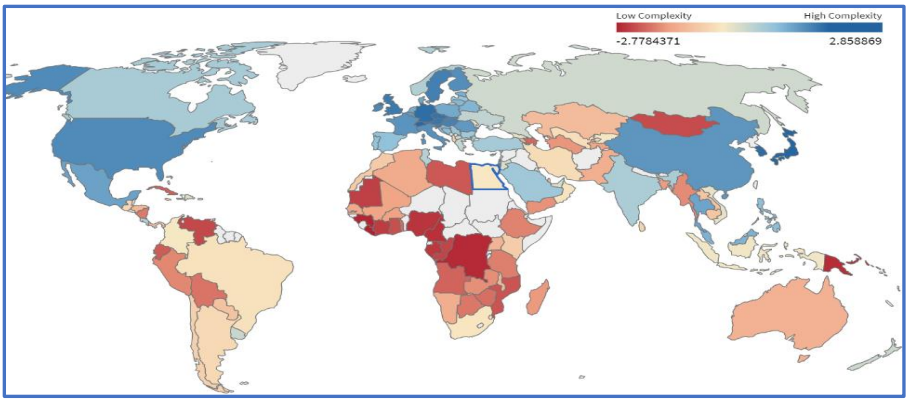
Figure 2 shows that industry value added as a percentage of GDP has steadily increased since 1990, reaching its highest values between 2012 and 2014, achieving about 40%. By 2022, it had increased to 32.7% of GDP. The value-added performance could be due to tax exemptions and government policies stimulating industrialization. Suggesting that the industry sector has become increasingly important to the Egyptian economy. The graph also illustrates that FDI net inflows as a percentage of GDP have been volatile during the same period. However, as it averaged below 4%, it peaked at 9.3% of GDP during its best performance period between 2005 and 2009. The volatility of FDI may be due to political instability, financial crises in 2007, and economic risks.

Figure 2: Progress of FDI and industry value added (%GDP)



Source: based on WDI (World Bank, 2023), available at: https://databank.worldbank.org/

Figure 3: Egypt's complexity ranking map.

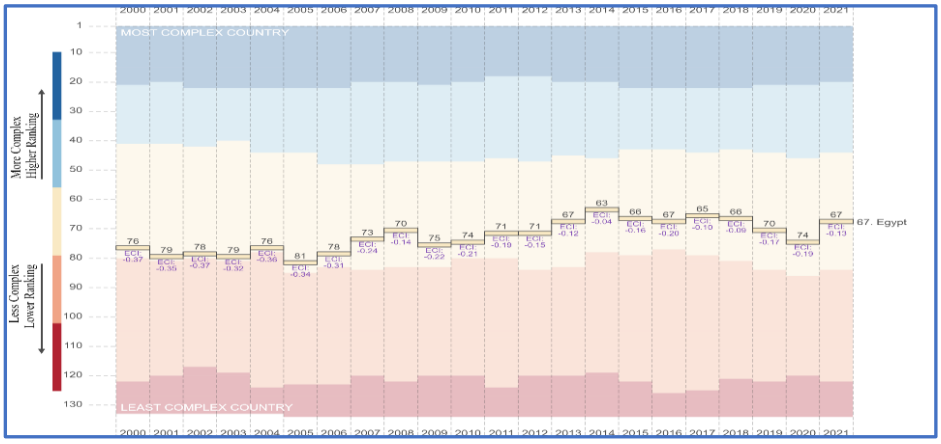


Source: (Harvard Growth Lab, 2022), available at: https://atlas.cid.harvard.edu/

Figure 3 affirms that Egypt ranked in the middle of the world map, superior to many African countries, but lags behind several MENA countries. Egypt's ECI ranking has declined over the twenty-first century's first decade. Suggesting that Egypt's exports have become less diversified and sophisticated. By 2011, Egypt witnessed a gradual increase in ECI, as shown in **Figure 4*Error! Not a valid bookmark self-reference.***. Despite the devaluation of the national currency in 2016, which is expected to have a greater impact on the level of exports and economic complexity, the ECI showed a slight improvement, followed by a significant decline during 2018

and 2019. The ECI decline could be attributed to reliance on oil exports and unfavorable government policies. In contrast, steps toward investment in education, training, and infrastructure would stimulate the investment and ECI climate.

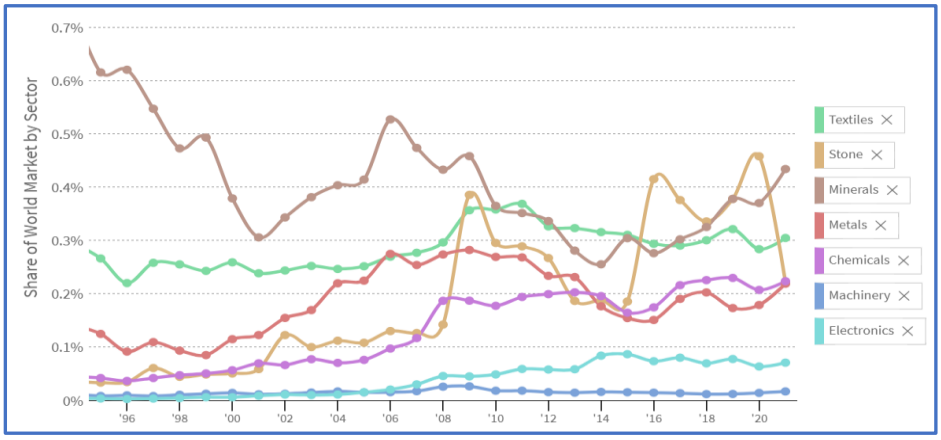
Figure 4: Egypt's complexity ranking over time.



Source: (Harvard Growth Lab, 2022), available at: https://atlas.cid.harvard.edu/

At the level of analyzing diversity in the Egyptian industry sector, the Harvard Growth Lab's data in **figure 5** shows that during the nineties, there was relative dominance of minerals products in the global market compared to the rest of the products of the industry sector, but this importance declined over time. On the other hand, it is noted that textile products have grown gradually from the mid-nineties until now and currently contribute about 0.3% of the global market. Moreover, chemical products contributed 0.1% at the beginning of the period, then grew by almost double their value. In addition, the contribution of electronics and machinery products is still very modest, highlighting the importance of direct FDI flows to these products seeking higher value added in the industry sector.

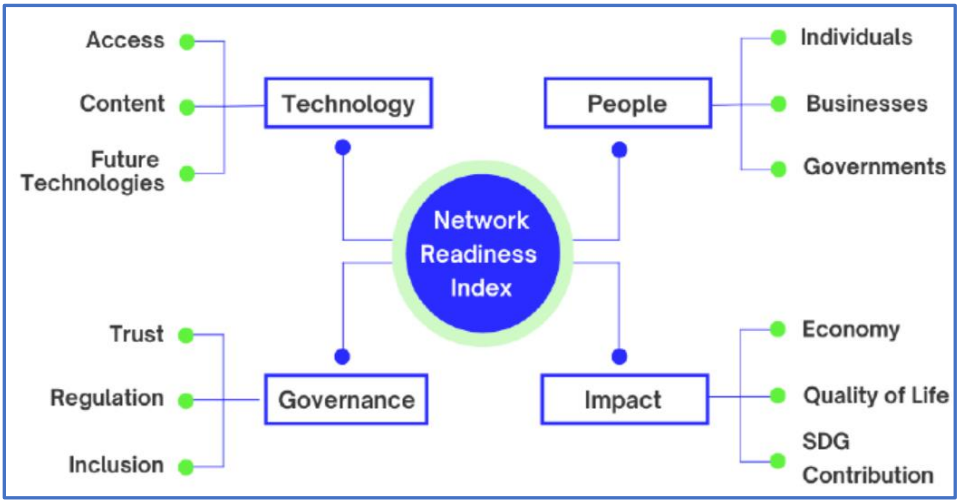
Figure 5: Egypt's global market share, 1995 - 2021.



Source: (Harvard Growth Lab, 2022), available at: https://atlas.cid.harvard.edu/

The network readiness index NRI[1] data evaluates the state of the Egyptian economy and the growth of its networks by considering the readiness of digital and technological networks, the skills of the workforce, and the technological infrastructure across four main pillars[2]. In 2022, Egypt ranked 73rd out of 131 economies, with a score of 4.38. The NRI score has improved by 0.15 points over the past two years. However, Egypt could also improve its NRI score by improving skills and knowledge regarding the people pillar. In addition, enhancing the regulatory environment would positively impact the governance pillar.

Figure 6: The NRI 2022 model



Source: (Portulans Institute, 2022), available at: https://networkreadinessindex.org/

Through this in-depth analysis of foreign direct investment flows in Egypt, as well as the analysis of the industrial sector, we could conclude the main opportunities and obstacles stimulating value-added and economic growth, paving the way for more conclusions regarding this relationship through the econometric analysis.

[1] NRI is one of the key metrics used to assess the state of an economy and its potential for generating profit.

[2] Technology, people, governance, and impact.

4 Model and Data Specification:

This section explains the model's development alongside the estimation approach and data employed to estimate the non-linear relationship between FDI inflows and industrial value-added in Egypt at the level of economic complexity.

4.1 Model Construction:

Given the purpose of the research, we will first use the generic logarithmic model shown in

Equation *1* below to shed light on the connection between FDI and industrial value-added in Egypt.

$$va_t = C + fdi_t + \sum_{k=1}^{K} \beta_k X_{it}^k + \epsilon_t$$

Equation 1

Where va_t represents the dependent variable, which is industrial value-added at time t, C represents the function's constant, fdi_t denotes the targeted independent variable, which is the foreign direct investment inflows into Egypt at time t. Additionally, X_{it}^k represents the vector of control variables, serving as potential determinants of industrial value-added apart from foreign direct investment. These variables encompass human development, trade openness, financial openness, economic growth, inflation, exchange rate, and institutional factors. The selection of these variables aligns with prior research studies. Finally, ϵ_t signifies the error term with its usual characteristics.

Given that the characteristics of foreign direct investments (FDI) inflows into countries heavily rely on the characteristics of their production, technological, and knowledge structures, as well as the accumulated levels of expertise and skills among their populations, the production system characteristics of specific countries will be a key determinant of the nature of incoming investments. In the case of developing countries with resource-based economies and limited skilled labor and expertise, FDI tends to lean towards labor-intensive activities aimed at producing low-tech, low-knowledge products, with a primary focus on cost reduction, such as textile manufacturing. However, as the economic systems of developing countries become more complex and their populations acquire greater skills and expertise, FDI inflows are inclined towards more technologically complex industries, such as automobile manufacturing and computer hardware production. This implies that the impact of foreign direct investment on the industrial value-added of host countries will fundamentally depend on the degree of economic complexity within these countries.

This implies that the relationship between foreign direct investment (FDI) and industrial value-added is nonlinear[3]. Consequently, The most appropriate standard approach to detect this non-linear structure is the Threshold Regression method, as proposed by (Hansen, 2000). This method specializes in identifying threshold values at which the model's predictive behavior significantly varies. As a result, it allows for the emergence of contrasting/divergent effects of foreign direct investment on industrial value-added based on the level of economic complexity. Hence, **Equation 1** can be extended to the following form:

$$va_t = C + \begin{cases} \beta_1 fdi_t & if\ \ eci < \lambda \\ \beta_2 fdi_t & if\ eci \geq \lambda \end{cases} + \sum_{k=1}^{K} \beta_k X_{it}^k + \epsilon_t$$

Equation 2

Where (eci, the level of economic complexity) represents the threshold variable used to divide the sample into regimes or groups and is an exogenous variable not included in the list of explanatory variables. λ is the unknown value of the threshold parameter (which is estimated using the least squares method). Consequently, the coefficient β_1 will reflect the impact of foreign direct investment on industrial value-added in Egypt at low levels of economic complexity, while the coefficient β_2 will reflect the same impact but at high levels of economic complexity. It is evident that under the null hypothesis $H_0; \beta_1 = \beta_2$, the model becomes linear, and **Equation 2** reduces to **Equation 1**. Thus, the final form of the study's model is as follows:

$$va_t = \beta_0 + \beta_1 fdi_t I(eci_t < \lambda) + \beta_2 fdi_t I(eci_t \geq \lambda) + \beta_3 hdi_t + \beta_4 to_t + \beta_5 fo_t + \beta_6 eg_t + \beta_7 inf._t + \beta_8 exc._t + \beta_9 ps_t + \epsilon_t$$

Equation 3

Where β_0 represents the constant term, eci_t denotes the level of economic complexity, and here, $I(.)$ is the indicator function, taking the value of 1 if the expansion in the indicator function is valid and 0 otherwise. This modeling strategy allows for varying the role of economic complexity depending on whether its level is lower or higher than the unknown threshold value λ. The following coefficients represent the control variables: hdi_t for human development level, to_t for trade openness, fo_t for financial openness, eg_t for economic growth, $inf._t$ for inflation level, $exc._t$ for the exchange rate and ps_t for political stability as a proxy for institutional quality.

[3] The non-linear relationship here is not required to take the shape of the letter U or the inverted letter U. But it can be positive in all its periods/levels, but with different regression coefficients.

4.2 Data:

To run the study's model, a wide range of data for Egypt was employed, drawn from multiple databases over the period from 1998 to 2021, encompassing a total of 24 annual observations. The selection of this time frame was based on the availability of economic complexity indicators. The study utilized the Industrial Value Added Index (% of Gross Domestic Product) to represent the dependent variable and the Net Inflows of Foreign Direct Investment (% of Gross Domestic Product) to represent the independent variable. As for the control variables, the study incorporated essential determinants of industrial development, including the Human Development Index, Merchandise Trade (% of Gross Domestic Product) as a proxy for trade openness, the Chinn & Ito Financial Openness Index, Gross Domestic Product Growth (economic growth), Annual Inflation (CPI), official Exchange Rate, and finally, the Political Stability and Absence of Violence Index as a proxy for institutional quality.

As for the threshold variable, which is the level of economic complexity, it serves as a comprehensive measure of a country's production system characteristics. The ECI illustrates the accumulated knowledge within a population of a country (and the networks that comprise the main sections), which is expressed in the country's industrial composition. Previously, the economic complexity measures were based on trade data, which, although internationally comparable, had the drawback of favoring countries closely connected to advanced economies. Recently, a new multidimensional approach to assessing economic complexity has been introduced. This approach involved integrating data on product-specific exports (ECI Trade), patenting by technology (ECI Technology), and scientific research papers (ECI Research) to estimate three independent measures of economic complexity. This multidimensional approach significantly enhances the ability of these methods to interpret economic performance. Moreover, a detailed description of the variables utilized and data sources are introduced in **Table 1** in the Appendix.

Table 1 and

Table 2 provide the descriptive statistics and correlation matrix for the variables used in the analysis, respectively. As depicted in **Table 1**, Egypt has experienced a decline in the inflow of foreign direct investment, averaging 2.6% annually during the period, which is a relatively low rate compared to many other developing countries. In

Figure 7 in the study's Appendix, it is observed that the industrial sector has consistently expanded since the early 1990s, reaching its peak at 39.9% of GDP in 2014. However, subsequent government policies led to a gradual contraction of this sector, reducing it to 31.2% of GDP by 2021.

From the same figure, we also observe a general upward trend in the level of economic complexity based on exports, which increased from -0.75 to -0.09 during the period. Meanwhile, economic complexity based on technological levels appears to be aligned with industrial value-added, increasing since the 1990s but declining after 2014 due to the contraction of the industrial sector during that period. As for economic complexity based on scientific research, the figure reveals fluctuations over the period, reflecting the inconsistency in Egyptian science and technology policies and the lack of a clear vision. On a scale between (-3) and (3) for economic complexity, it becomes evident that the Egyptian economy remains at a relatively rudimentary level.

Additionally, from

Table 2, we observe an extremely weak and statistically insignificant negative correlation (-23.9%) between foreign direct investment and industrial value-added. This can primarily be attributed to the non-linear relationship between them, which necessitated the use of threshold regression. Conversely, we find a statistically significant moderate positive correlation at the 1% level between industrial value-added and economic complexity based on technology (67.4%), as well as economic complexity based on exports (54%). However, the correlation between industrial value-added and economic complexity based on research is weak and statistically insignificant (28.8%). This suggests that Egyptian industrial policy does not heavily rely on developing the domestic industrial sector through local research and development to build competitive advantages. Moreover, it is noteworthy that the control variables with the highest correlations to industrial value-added were trade openness (68.1%), followed by political stability (-67.7%), inflation (61.6%), human development (39.3%), financial openness (-35.1%), economic growth (-31.2%), and finally, exchange rate (25.6%).

Table 1: Descriptive summary statistics

	Unit	*Obs.*	*Mean*	*Median*	*Std. Dev.*	*Min*	*Max*	*Normality test*
Dependent variable:								
Industrial value added (VA)	(% of GDP)	24	34.40	34.87	3.108	28.40	39.89	[0.2279]
Independent variable:								
FDI, net inflow	(% of GDP)	24	2.638	1.558	2.505	-0.205	9.349	[11.759][a]
Threshold variables:								
ECI Trade	(-3 to 3)	24	-0.328	-0.310	0.180	-0.748	-0.089	[1.3779]

ECI Technology	(-3 to 3)	23	-0.142	-0.042	0.352	-1.041	0.296	[2.8038]
ECI Research	(-3 to 3)	23	0.162	0.239	0.312	-0.484	0.581	[3.1424]
Control variables:								
HDI	(0 to 1)	24	0.676	0.672	0.038	0.624	0.735	[2.1590]
Trade openness (to)	(% of GDP)	24	31.05	31.94	7.902	18.83	45.82	[1.3659]
Financial openness (fo)		24	0.664	0.747	0.317	0.164	1	[2.3981]
Economic growth (eg)	(annual %)	24	4.429	4.359	1.598	1.765	7.156	[0.9979]
Inflation, CPI (inf.)	(annual %)	24	9.076	9.236	6.045	2.269	29.51	[23.033]^{a}
Exchange rate (exc.)	(LCU per US$)	24	7.996	5.892	4.820	3.388	17.78	[5.5537]^{c}
Political Stability (ps)	(0 to 100)	24	21.37	20.39	13.10	6.635	47.62	[2.1387]

***Note*:** a, b, and c indicate significance at 1%, 5% and 10%, respectively.

Table 2: Correlation matrix between study variables

		(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*	*(9)*	*(10)*	*(11)*
ln Industrial value added	**(1)**	1										
ln FDI, net inflow	**(2)**	0.239	1									
ECI Trade	**(3)**	0.540^{a}	0.296	1								
ECI Technology	**(4)**	0.674^{a}	0.434^{b}	0.560^{a}	1							
ECI Research	**(5)**	0.288	0.364^{c}	0.482^{b}	0.505^{b}	1						
ln HDI	**(6)**	0.393^{c}	0.051	0.912^{a}	0.447^{b}	0.425^{b}	1					
ln Trade openness	**(7)**	0.681^{a}	0.611^{a}	0.428^{b}	0.674^{a}	0.334	0.192	1				
ln financial openness	**(8)**	-0.351^{c}	0.133	-0.582^{a}	-0.246	-0.383^{c}	-0.689^{a}	0.134	1			
ln Economic growth	**(9)**	-0.312	0.714^{a}	-0.069	0.002	0.254	-0.203	0.141	0.301	1		
ln Inflation, CPI	**(10)**	0.616^{a}	0.419^{b}	0.713^{a}	0.716^{a}	0.512^{b}	0.555^{a}	0.718^{a}	-0.337	0.096	1	
ln Exchange rate	**(11)**	0.256	0.143	0.870^{a}	0.337	0.155	0.914^{a}	0.223	-0.503^{b}	-0.085	0.537^{a}	1
ln Political Stability	**(12)**	-0.677^{a}	0.133	-0.742^{a}	-0.578^{a}	-0.376^{c}	-0.799^{a}	-0.317	0.737^{a}	0.553^{a}	-0.601^{a}	-0.642^{a}

***Note*:** a, b, and c indicate significance at 1%, 5% and 10%, respectively.

5 Econometric Analysis and Results:

5.1 Unit Root test:

The initial step in the standard analysis involves verifying the stationarity of the time series and determining the integration order of each series in the model in order to avoid spurious regression. The unit root test is widely recognized as one of the most essential and prominent methods employed for testing stationarity. As elucidated by (Fuller, 1976), unit root tests are not necessarily robust, and it is advisable to employ multiple

tests. Consequently, we will utilize the augmented Dickey-Fuller (ADF) test and the highly utilized Phillips-Perron (PP) test in applied research to ascertain stationarity and ensure the robustness of the results.

Table 2 in the study appendix presents the stationarity results.

Since (Perron, 1989), the time series literature has emphasized the importance of structural breakpoints when studying unit root tests for time series. Perron clarified that the presence of structural breakpoints in time series causes the traditional ADF test to be biased towards not rejecting the null hypothesis, i.e., it becomes biased towards a false unit root. However, both (Nunes et al., 1997) and (Bai & Perron, 1998) emphasized the necessity of pre-confirming the existence of a breakpoint in the series. If there is no structural break (a structural change), and a unit root test is conducted under the assumption of a structural break, the result will be a spurious break. In this case, the unit root test tends to estimate a breakpoint in the middle of the series, even though there is no actual breakpoint.

Therefore, unit root tests cannot be relied upon in the following cases: i) when there is a structural break, but it is not included in the test regression, ii) if there is no breakpoint, but it is included in the test regression, iii) using an incorrect date for the breakpoint in the test regression (especially in tests where the breakpoint is externally specified). Hence, the study by (Shrestha & Chowdhury, 2005) emphasized the necessity for researchers to apply judgment based on economic theory to make assumptions about the nature of time series .

Consequently, we will rely on the Dickey-Fuller test with a breakpoint and the test, which represents an extension of the Perron test when there is only one unknown internal structural breakpoint. **Table 4** illustrates the stationarity results in the presence of a structural break. Therefore, based on

Table 2,

Table 3, and **Table 4,** we have confirmed the stationarity of variables as a prerequisite for the application of threshold regression, except for the inflation variable. Consequently, taking the first difference of this non-stationary variable will be required to render it stationary.

5.2 Threshold Regression Estimate:

Before estimating the study's model, it is essential to ensure the quality of the regressors used in the analysis and verify their freedom from various econometric problems. This was confirmed through **Table 5** in the study's Appendix. Based on this, the study's model was estimated, as shown in

Table 3 below, which reveals several interesting results.

Table 3: FDI, Industrial value added and Economic complexity: Empirical results.

Dependent Variables: *ln Industrial value added (% of GDP)*

Economic complexity: *ECI Trade, ECI Technology, ECI Research*

Method: Discrete Threshold Regression

	Reg (1)	***Reg (2)***	***Reg (3)***	***Reg (4)***
	Linear model ARDL without threshold	**Threshold model**		
		λ = *ECI Trade*	λ = *ECI Technology*	λ = *ECI Research*
ln FDI (without threshold)	0.0023 [0.087]			
Constant	3.3352 [11.19]***			
		Threshold Variables		
		(When λ < -0.301)	**(When λ < -0.022)**	**(When λ < -0.351)**
ln FDI (when ECI < λ)		-0.0631 [-2.538]**	-0.1099 [-8.798]***	-0.0829 [-2.038]*
Constant		4.1623 [11.13]***	4.7632 [22.52]***	3.4322 [8.213]***
			(-0.022 ≤ λ < -0.170)	
ln FDI (when λ ≤ ECI < λ)			0.0972 [5.577]***	
Constant			4.3658 [22.51]***	
		(When λ ≥ -0.301)	**(When λ ≥ 0.170)**	**(When λ ≥ -0.351)**
ln FDI (when ECI ≥ λ)		0.0976 [2.933]**	0.0646 [2.772]**	0.1228 [2.345]**
Constant		3.8858 [11.22]***	4.4985 [22.13]***	3.1614 [8.497]***
			Non-Threshold Variables	
ln HDI	2.1216 [4.099]**	1.1295 [7.049]**	1.4896 [6.050]***	0.0502 [0.099]
ln Trade openness	0.3539 [3.708]**	0.2313 [3.929]***	0.2445 [9.076]***	0.3138 [4.281]***
ln financial openness	-0.1013 [-3.980]**	0.0542 [1.838]*	0.0448 [3.729]***	0.0220 [0.473]
ln Economic growth	0.2338 [3.239]**	0.0708 [1.779]	0.1494 [6.958]***	0.0867 [1.489]
ln Inflation, CPI	0.0009 [0.058]	-0.0499 [-2.642]**	-0.0733 [-8.238]***	-0.0599 [-2.331]**
ln Exchange rate	-0.0869 [-4.009]**	-0.1361 [-4.594]***	-0.2734 [-11.58]***	-0.1255 [-2.989]**
ln Political Stability	0.2137 [3.451]**	-0.1925 [-4.222]***	-0.2701 [-12.29]***	-0.2008 [-2.804]**
		Effects Specification		
Obs.	24	24	23	23
Adjusted R^2	98.6%	89.9%	97.9%	81.8%
No. of threshold variable lags	-	(-2)	(-3)	(-2)
Fisher test (F-stat.)	(80.961)***	(19.765)***	(73.067)***	(9.9655)***
F-bounds test	(48.791)***	-	-	-

	Model selection criteria			
Akaike info criterion	-6.8397	-4.3219	-6.1463	-3.8271
Schwarz criterion	-5.8974	-3.7764	-5.4991	-3.2799
Hannan-Quinn criterion	-6.6177	-4.1934	-6.0199	-3.7083
Log-likelihood	94.236	19.765	74.463	51.184

Note: - ***, **, * indicate significance at 1%, 5% and 10% respectively.

- Results correspond to a trimming percentage of 0.15, Max. thresholds 5, Sig. level 0.05.

Regarding Regression (1), which represents the linear form of the study's model (without considering thresholds in the regression), it becomes evident that there is no significant impact of foreign direct investment inflows on industrial value-added in Egypt. This result may be attributed to the non-linear relationship between investment and value-added, which could depend on the characteristics of the Egyptian production system, which encourages utilizing the threshold regression. As for the impact of control variables, there is a positive effect of human development, trade openness, economic growth, and political stability on industrial value-added, all of which align with the expected economic theory since they represent fundamental determinants in the development of any country's industrial sector. On the contrary, there is a negative impact of financial openness and exchange rate on industrial value-added. In contrast, inflation did not appear to have any significant effect on industrial value-added.

To answer the question of how the level of economic complexity affects the relationship between foreign direct investment and industrial value-added, we transitioned to threshold regression (as shown in

Table 3). The regressions (2), (3), and (4) illustrate this, where the only difference between these regressions is the complexity index used as the threshold for segmentation. Regression (2), which used the Economic Complexity Index based on the type of country exports (ECI Trade) as the threshold indicator, shows a non-linear relationship between foreign direct investment and industrial value-added based on the level of economic complexity focused on exports. This non-linear relationship takes the form of a U-shape. In other words, the impact of foreign direct investment on industrial value-added is negative when the level of economic complexity in the Egyptian economy based on exports falls below the threshold level, which is represented by a coefficient of -0.301 in regression (2). However, the effect of foreign direct investment on industrial value-added becomes positive above this threshold level.

In regressions (3) and (4), these non-linear relationships are confirmed, and the primary difference lies in the threshold value. In regression (3), which used the Economic Complexity Index based on technology (ECI Technology) as the threshold indicator, the threshold value is -0.022. In regression (4), which used the Economic Complexity Index based on research areas (ECI Research) as the threshold indicator, the threshold value is -0.351. From regression (3), it is observed that the positive impact of foreign direct investment on industrial value-added decreases relatively when the

complexity of the Egyptian economy exceeds -0.022 based on technological complexity. This implies that as the technological level of the Egyptian industrial sector increases, building local competitive advantages becomes necessary, rather than relying solely on the transfer of technological transactions from abroad through foreign direct investment.

Therefore, these results substantiate the assumptions made in the model-building section of the study. As the complexity of the Egyptian economy increases, which includes an accumulation of knowledge and expertise among the population reflected in the heightened sophistication of exportable industrial goods, it becomes more capable of attracting technologically advanced foreign investments. Consequently, this supports the advancement of the Egyptian industrial sector and vice versa. A comparison of the threshold regression results reveals that the expansion of the Egyptian industrial sector requires a level of technological-based economic complexity (at -0.022) significantly greater than the complexity rooted in exports (at -0.301) or research (at -0.351). This underscores the importance of actively fostering technological capabilities to empower foreign investment flows in increasing industrial value-added.

Finally, the overall statistics indicate an increase in the Adjusted R^2 value of the model, with the regressions employed explaining 81.8% to 98.6% of the variations in industrial value-added. Additionally, the Fisher test indicates statistical significance for the entire study model across all regressions in the table.

6 Conclusion and policy implications:

This study investigated the re betwlationship been foreign direct investment (FDI) and industrial value-added in Egypt using economic complexity as a threshold variable. From 1998 through 2021, a large dataset was used to study these trends. This research shows the complicated effects of FDI on industrial development in Egypt and the importance of economic complexity to boost the country's industrial sector.

The initial linear regression found no significant link between FDI and industrial value-added in Egypt, indicating a need for threshold regression models. Control variables like human development, trade openness, economic growth, and political stability had positive effects as expected. Economic complexity, assessed through exports, technology, and research, revealed non-linear relationships with FDI and industrial value-added. Economic complexity influenced this relationship, with exports showing a U-shaped pattern. Technology and research had their own threshold values, emphasizing the importance of technological advancement and research capabilities for industrial growth and FDI attraction.

Egyptian policymakers should prioritize boosting economic complexity in areas such as exports, technology, and research. This entails investments in education, innovation, and the growth of high-value industries to create an environment more appealing to FDI. Recognizing the non-linear FDI-industrial value-added

relationship, policymakers should adopt a targeted approach. They should attract investments aligned with Egypt's economic complexity and technological capabilities, offering incentives to industries that match the country's profile. Improving human development is crucial for nurturing a skilled workforce capable of contributing to a more complex and diversified industrial sector. Education and training programs should adapt to the evolving needs of tech and research-focused industries. Maintaining a stable political environment and open trade policies should remain top government priorities as these factors significantly contribute to industrial development.

In conclusion, this research sheds light on the complex relationship between FDI, economic complexity, and industrial value-added in Egypt. The results underscore the need for a nuanced approach to promot FDI and foster industrial development. By strategically aligning foreign investments with Egypt's economic complexity and by investing in human capital and innovation, the country can set the stage for sustainable industrial growth and economic prosperity. These policy insights hold significance for policymakers struggling with the challenges of industrial development in a rapidly evolving global economy. These findings should be considerd with the following limitations, that this study is based on data up to 2021, focused on Egypt, and relies on specific economic complexity metrics. Future research can overcome these limitations by conducting longitudinal analyses, cross-country comparisons, and qualitative investigations. Moreover, exploring causality, evaluating policy interventions, and examining the interplay of various economic complexity dimensions offer promising avenues for advancing our comprehension of the FDI-industrial development relationship.

7 References:

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8 Appendix:

Table 4: Description of the study variables

Data	*Description*	*Source*
Industrial value added	The Value Added by Industry (% of Gross Domestic Product) represents the net output of the industrial sector after aggregating all outputs and subtracting intermediate inputs. This industrial sector aligns with sectors 10 to 45 in the International Standard Industrial Classification (ISIC). It encompasses the value added in manufacturing (ISIC sectors 15 to 37), mining, construction, electricity, water supply, and gas.	(WBI)
FDI, net inflow	Foreign Direct Investment, Net Inflows (% of Gross Domestic Product); this represents the net inflow of foreign investment to acquire a lasting interest (10 percent or more of the voting stock) in an enterprise operating in an economy other than that of the investor. It includes capital ownership shares and the reinvestment of earnings, as well as other long-term and short-term capital.	(IMF)
ECI Trade	Economic Complexity Index: Economic Dimension: this is a measure of the relative knowledge density of an economy or product based on trade data. Its values range from (-3) to (3).	(ATLAS)
ECI Technology	Economic Complexity Index: Technological Dimension: this is a measure of the relative knowledge density of an economy or product based on patent data. Its values range from (-3) to (3).	(ATLAS)
ECI Research	Economic Complexity Index: Research Dimension; this is a measure of the relative knowledge density of an economy or product based on scientific papers published by the field of study. Its values range from (-3) to (3).	(ATLAS)
HDI	The Human Development Index (HDI) is a composite index that measures average achievements in three fundamental dimensions of human development over the long term: longevity, knowledge, and a decent standard of living. For measurement purposes, it is summarized into four indicators: life expectancy at birth, mean years of schooling and expected years of schooling, and per capita gross national income at purchasing power parity. The value of the index ranges between 0 and 1.	(UNDP)

Trade openness	Merchandise Trade (% of Gross Domestic Product): this represents the value of merchandise exports and imports divided by the total Gross Domestic Product, all data presented in current US dollars.	(WBI)
Financial openness	The Financial Openness Index is an indicator that measures the degree of capital account openness in a country. It was initially introduced by Chinn & Ito in the Journal of Development Economics in 2006. This index relies on binary dummy variables that record the restrictions imposed on cross-border financial transactions as reported in the International Monetary Fund's Annual Report on Exchange Arrangements and Exchange Restrictions.	(CI)
Human capital	Gross Domestic Product (GDP) Growth (% annually): this is the annual growth rate of the Gross Domestic Product at market prices, based on a constant local currency. The figures are based on a fixed price for the US dollar in 2010.	(WBI)
Inflation, CPI	Inflation, Consumer Prices (% annually); this reflects the annual percentage change in the cost that the average consumer pays for a basket of goods and services that can fluctuate over specified periods, typically measured on an annual basis. It is generally calculated using the Laspeyres formula.	(WBI)
Exchange rate	Official Exchange Rate (Local Currency against US Dollar, Average Period): this refers to the exchange rate determined by national authorities or the rate allowed by law in the official exchange market. It is calculated as an annual average based on monthly averages (local currency units per US dollar).	(WBI)
Political Stability	Political Stability and Absence of Violence Index: this is one dimension of good governance that measures perceptions of the likelihood of destabilization or overthrow of the government, whether by violent or unconstitutional means, including political violence and terrorism. Its values range from 0 (lowest rank) to 100 (highest rank).	(WBI)

Note: WBI: World Development Indicators, **IMF:** International Monetary Fund, **ATLAS:** The Atlas of Economic Complexity database, **UNDP:** United Nations Development Program, **CI:** Chinn & Ito database, **WGI:** The Worldwide Governance Indicators.

Table 5: Standard Unit root test results

Variables	*Augmented Dickey-Fuller*			**Result**	*Phillips-Perron*			**Result**
	Intercept	*Intercept & trend*	*None*		*Intercept*	*Intercept & trend*	*None*	
ECI Trade	-2.2625	-3.3388[c]		*I(0)*	-2.7839[c]			*I(0)*
ECI Technology	-1.6379	-1.3014	-1.5187	*I(1)*	-2.7061[c]			*I(0)*
D(ECI Technology)	-3.5836[b]							
ECI Research	-2.7509[c]			*I(0)*	-1.7483	-2.1638	-1.5637	*I(1)*
D(ECI Research)					-2.4843	-2.4432	-2.5621[b]	
ln HDI	-0.8362	-2.4352	-1.3634		-0.1712	-1.7420	-5.0803[a]	
D(ln HDI)	-1.6876	-1.4684	-1.3452	*I(2)*				*I(0)*
D1(ln HDI)	-5.0962[a]							
ln Inflation, CPI	-1.8406	-1.6784	-0.4104	*I(1)*	-1.8406	-1.7575	-0.4104	*I(1)*
D(ln Inflation, CPI)	-4.9119[a]				-4.9134[a]			
Critical Values	***ADF***				***PP***			
1%	-3.7696	-4.4407	-2.6743		-3.7529	-4.4163	-2.6694	
5%	-3.0049	-3.6329	-1.9572		-2.9981	-3.6220	-1.9564	
10%	-2.6422	-3.2547	-1.6082		-2.6388	-3.2486	-1.6085	

Note: a, b, and c indicate significance at 1%, 5% and 10%, respectively.

Table 6: Additional Standard Unit test results

		DF-GLS (ERS)		*KPSS*		*ERSPO*	
		Intercept	Intercept and trend	Intercept	Intercept and trend	Intercept	Intercept and trend
ECI Technology		-1.7346		0.3482		11.408	29.938
ECI Research		-2.8278		0.2555	0.1025	1.2603	
ln HDI		-1.2480	-2.5330	0.6925		74.829	4.0810
D(ln HDI)		-1.8313					
	1%	-2.6924	-3.7700	0.7390	0.2160	1.8700	4.2200
Critical Values	5%	-1.9602	-3.1900	0.4630	0.1460	2.9700	5.7200
	10%	-1.6071	-2.8900	0.3470	0.1190	3.9100	6.7700

Table 7: Breakpoint Unit root test results

Break Specification: *Intercept only*

Break Type: *Innovational outlier*

Variables	*Dickey-Fuller*				*Zivot and Andrews*				***Result***
	Intercept	*Intercept & trend*	*Trend*	Year of Break	*Intercept*	*Intercept & trend*	*Trend*	Year of Break	
ln Industrial value added	-3.2008	-4.5513	-4.7366[a]	2014					*I(0)*
ln FDI, net inflow	-4.6919[b]			2011					*I(0)*
ln Trade openness	-3.3698	-4.9188	-5.2961[a]	2008					*I(0)*
ln financial openness	-7.1594[a]			2012					*I(0)*
ln Economic growth	-5.1256[a]			2010					*I(0)*
ln Exchange rate	-10.497[a]			2016					*I(0)*
ln Political Stability	-6.8592[a]			2010					*I(0)*
Critical Values	***Level***				***First difference***				
1%	-4.95	-5.72	-5.067		-4.95	-5.72			
5%	-4.44	-5.18	-4.525		-4.44	-5.18			
10%	-4.19	-4.89	-4.261		-4.19	-4.89			

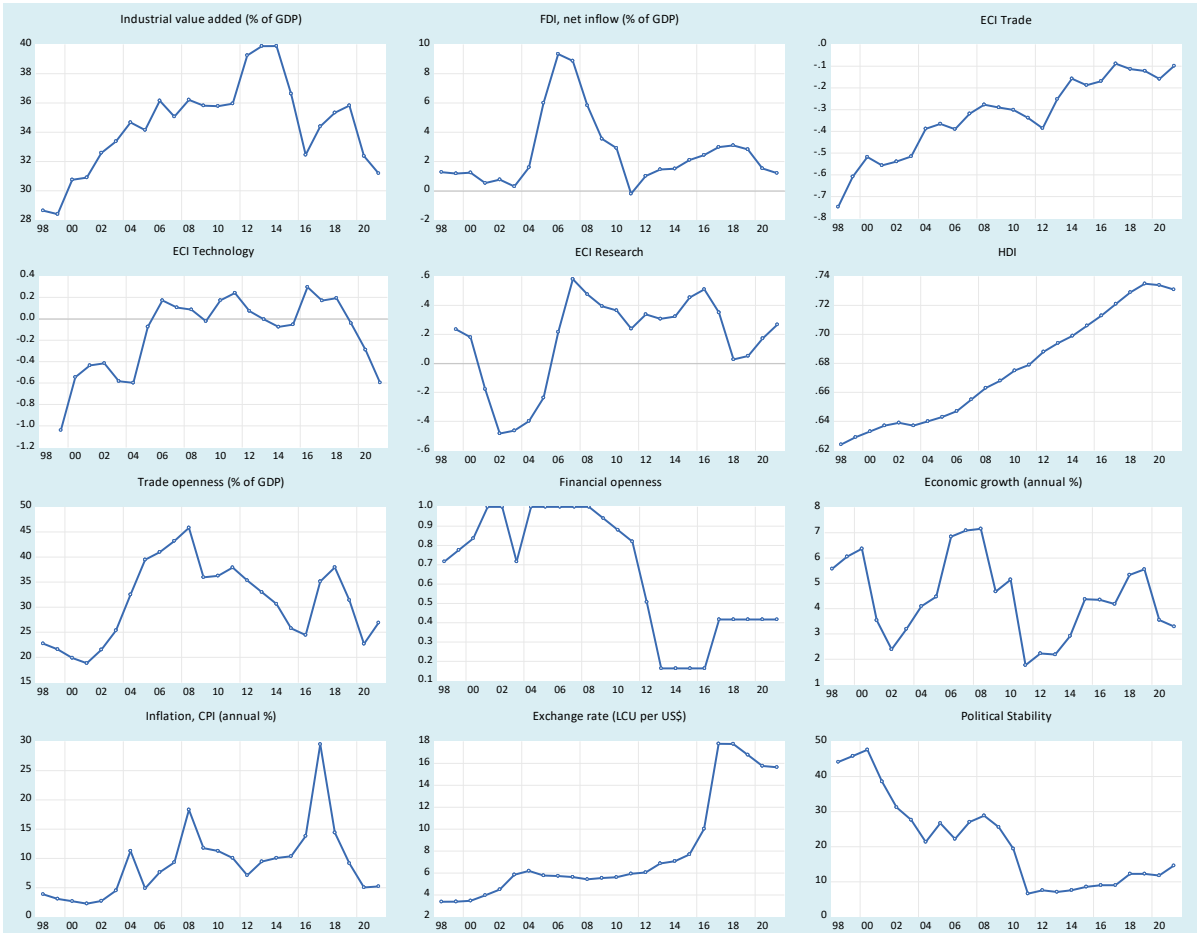
Note: a, b, and c indicate significance at 1%, 5% and 10%, respectively.

Table 8: Diagnostic tests results

	Tests used	***t-stat.***			
		Reg (1)	**Reg (2)**	**Reg (3)**	**Reg (4)**
Heteroskedasticity	White's test	[4.4166]	[1.6956]	[3.9136][b]	[0.4198]
Serial Correlation	Wooldridge test	[2662.6][b]	[1.7482]	[14.436][a]	[2.2194]
Normality	Jarque-Bera	[0.6569]	[1.0517]	[0.3805]	[0.2927]
Function Form	Ramsey RESET Test	[0.5539]	[2.7893]	[0.0026]	[0.1936]
Influential observations	Leverage test	No leverage points were found			
Collinearity	Variance Inflation Factors (VIF)	All values more than 10			

Note: a, b, c indicate significance at 1%, 5% and 10% respectively.

Figure 7: Variables trend during the period (1998-2021)



9 الملخص:

يستهدف هذا البحث التطرق إلى العلاقة المعقدة بين الاستثمار الأجنبي المباشر والقيمة المضافة الصناعية في مصر، مع التركيز على التعقيد الاقتصادي كعامل محوري، وذلك بتطبيق تقنيات قياسية متقدمة على البيانات من عام 1998 إلى عام 2021، بما في ذلك تحليل انحدار العتبات، والتي تكشف عن الديناميكية غير الخطية لتأثير الاستثمار الأجنبي المباشر على القطاع الصناعي في مصر. وبذلك تخالف نتائج الدراسة النماذج الخطية التقليدية، حيث تبين أن تأثير الاستثمار الأجنبي المباشر على القيمة المضافة الصناعية ليس واضحاً. كما تبرهن الدراسة على أن المتغيرات التابعة مثل التنمية البشرية، والإنفتاح التجاري، والنمو الاقتصادي، والإستقرار السياسي لهم آثاراً إيجابية كبيرة على القيمة المضافة الصناعية، وهذا ما يتفق مع النظريات الاقتصادية الراسخة. والأهم من ذلك أن الدراسة تقدم التعقيد الاقتصادي كعامل محوري في تشكيل العلاقة بين الاستثمار الأجنبي المباشر والقيمة المضافة الصناعية وذلك من خلال ثلاثة أبعاد للتعقيد الاقتصادي كالصادرات، والتكنولوجيا، والبحث العلمي بما يمثل مؤشرات للعتبة. ولكل بعد منهم قيمة عتبة فريدة، وهو ما يسلط الضوء على أهمية تعزيز التعقيد الاقتصادي في مختلف الجوانب لجذب الاستثمار الأجنبي المباشر وتعزيز التنمية الصناعية . وعلى وجه التحديد، تبرز دراستنا شكل العلاقة بين الاستثمار الأجنبي المباشر والقيمة المضافة الصناعية والتي تكون علي شكل حرف U ، حيث يكون للاستثمار الأجنبي المباشر تأثير سلبي عندما يكون التعقيد الاقتصادي أقل من عتبة معينة ولكنه يصبح إيجابياً عندما يتجاوز التعقيد ذلك الحد. وهو ما يؤكد علي ضرورة تبنى سياسات من شأنها أن تعزز التنوع والتطور الاقتصادي. علاوة على ذلك، تؤكد الدراسة على أهمية التكنولوجيا والتعقيد الاقتصادي القائم على الأبحاث في ظل نمو القدرات التكنولوجية والبحثية، ولذلك فإن جذب الاستثمار الأجنبي المباشر يعتمد على بناء القدرات المحلية وليس مجرد نقل التكنولوجيا. و يقدم البحث رؤية واضحة لصانعي السياسات تركز على أهمية الترويج الإستراتيجي للاستثمار الأجنبي المباشر بما يتماشى مع التعقيد الاقتصادي للدولة. وهذا يعني ضمناً الحاجة إلى الاستثمار في رأس المال البشري، وتعزيز التعقيد الاقتصادي، وتنفيذ سياسات قابلة للتكيف تستجيب للمشهد المتطور المعقد. وتوفر هذه النتائج أساسًا قويًا لمعالجة تحديات التنمية الصناعية في اقتصادنا العالمي المترابط بشكل متزايد.