

The Impact of Foreign Direct Investments on the Performance of Egyptian Stock Market Sectors Using Machine Learning Techniques

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Abstract

This study attempts to investigate the impact of foreign direct investments, represented by net foreign direct investment, considering economic changes on the Performance of Egyptian Stock Market Sectors. This has been applied on 13 sectors in the Egyptian exchange on an annual basis during 2007-2021. The stock return is measured by calculating the change in sectoral indices. Additionally, this study employs Panel Generalized Method of Moments (GMM), Support Vector Regression (SVR), and K-Nearest Neighbors (k-NN) to compare the results and identify the best approach in prediction.

The findings indicate that there is a positive impact of foreign direct investments on sectors' performance. Macroeconomic factors, including GDP growth, inflation, real interest rate, and market capitalization, are also identified as determinants of performance of exchange sectors. The results reveal that the model based on the K-Nearest Neighbors approach performs better in prediction compared to other techniques. The empirical results provide several practical implications and new insights for policymakers and investors, highlighting the need for further studies can examine the impact of decision of investments on the financial performance under unstable political and health conditions.

Keywords: Egyptian stock market sectors, foreign direct investments, K-Nearest neighbors, macroeconomic factors, stock market return, support vector regression

1. Introduction

Foreign Direct investment (FDI) is an investment which investors from other countries invest in or set up in another country's business and it is an investment of multinational companies or organization in developing countries (Nwanji et al., 2020). According to the important role that foreign direct investment plays in the economy growth, where FDI achieve better governance and facilitate stock market progress due to spillover effects that can generate investment opportunities, which in turn leads to a more developed financial market (Tran & Huynh, 2022). Therefore, the government tries continuously to attract foreign investments inside the country by following different policies. Although there have been many studies focusing on the impact of FDI on various industries, only a limited number of studies have been devoted to the impact of FDI on the performance of stock market sectors, especially in Egypt.

Given the diverse advantages of FDI and potential research dearth on FDI and stock market sectors nexus in prior literature, especially in Egypt, this motivated the conduct of this study. It's noteworthy, interest to study in the relation between foreign direct investment (FDI) and financial performance and development has been focused between academics and investors (Boboye, 2014; Alsmadi & Oudat, 2019; Parvez & Azhar, 2019; Nwanji et al., 2020; Majeed et al., 2021; Tran & Huynh, 2022; Hafiluddin & Patunru, 2022; Khan et al., 2023; Alzarooni et al., 2024).

Some research examined the relationship between FDI and financial performance and inclusion (Parvez & Azhar, 2019; Nwanji et al., 2020; Khan et al., 2023; Alzarooni et al., 2024). Other research revealed that FDI has a positive impact on financial development (Alsmadi & Oudat, 2019; Majeed et al., 2021; Tran and Huynh, 2022). Nevertheless, some research showed reverse evidence: FDI and financial sector development has a negative relation with economic growth (Boboye, 2014), or no strong relationship with company productivity (Hafiluddin & Patunru, 2022). Considering published literature, it is exciting that the studies available until the current show

mixed outcomes; positive, negative, and non-significant, making it even more challenging to conclude (Tran & Huynh, 2022).

Although the evidence of FDI and its influence on financial performance and development for both the banking and companies, the findings from the stock market sector remain limited and inconclusive. Hence, there is a paucity of studies that may be able to provide evidence of FDI and its influence on sectors' performance. Since the impact of FDI on stock market sectors is considered understudied and not yet subjected to proper empirical evaluation, this study plans to close the gap by investigating the effect of FDI on stock market sectors using machine learning techniques approach, which can provide higher estimation results. Therefore, this study seeks to fill this gap by addressing the debate over whether FDI would improve, reduce, or have no impact on the performance of stock market sectors using machine learning techniques. Additionally, it significantly expands the literature by investigating how FDI impacts performance of stock market sectors over 15 years.

Notably, this study seeks to check whether there is a significant effect of FDI on performance of stock market sectors in Egypt. Substantially, this study's objective is to investigate the impact of FDI on sectors' Performance to fulfill an existing research gap regarding: (a) applying to 13 stock market sectors, (b) covering 15 years from 2007 to 2021 and (c) employing the methodology of machine learning techniques to compare the results and identify the best approach in prediction. Additionally, this study attempts to identify the significant factors that may have an impact on sectors' performance, where it considers both the market characteristics and macroeconomic variables.

The findings reveal that there is a significant positive impact of FDI on sectors' performance. The outcomes also reveal that some factors play an important role, which are identified as determinants of performance of stock market sectors, including GDP growth, inflation, real interest rate, and market capitalization. The results show that the model based on the K-Nearest Neighbors approach performs better in prediction compared to other techniques. Strikingly, the results provide new insights for policymakers and investors, presenting several practical implications for crafting policies that are adaptive to economic conditions and contributing to more effective decision-making related to investment policies in sectors and how to attract and manage foreign investment. Future studies could check the impact of decision of investments on the financial performance under unstable political and health conditions or focus on the relationship between FDI and financial inclusion under digital economy.

This study is organized as follows: section 2 presents the problem statement, while section 3 reviews the literature and hypotheses. Section 4 shows the data, variables development and the methodology used. Section 5 highlights the results of the hypotheses test and comparison the results using machine learning techniques while section 6 concludes and makes recommendations for future research.

2. The Problem Statement

Foreign Direct investment fulfils as a centric source of capital formation in any country for its economic development in a significant manner, especially in developing countries. This field has attracted the interest of some academics to examine the relationship between foreign investment and financial performance.

Interestingly, some studies focus on examining the relation between FDI and financial sector and show that FDI enhance both financial performance and inclusion (Parvez & Azhar, 2019; Nwanji et al., 2020; Khan et al., 2023; Alzarooni et al., 2024). Other studies revealed that FDI has a positive impact on financial development (Alsmadi & Oudat, 2019; Majeed et al., 2021; Tran & Huynh, 2022), or no strong relationship with company productivity (Hafiluddin & Patunru, 2022) or FDI and financial sector development has a negative impact on growth (Boboye, 2014). Obviously, these empirical findings are mixed.

Prior studies have produced conflicting and ambiguous results, hence further examination of this crucial relationship is needed. However, the impact of FDI on stock market sectors, especially in Egypt, has received less attention, leaving a notable research gap. This study contributes to literature by bringing evidence from Egyptian exchange sectors using machine learning methods, that is less examined in the literature. This study applied to 13 sectors and covered over 15 years. Moreover, the economic factors and market characteristics effect have been addressed. The following graphs that show the evolution of FDI and performance of stock market sectors in Egypt during 2016-2021, as shown in figure 1 & 2:

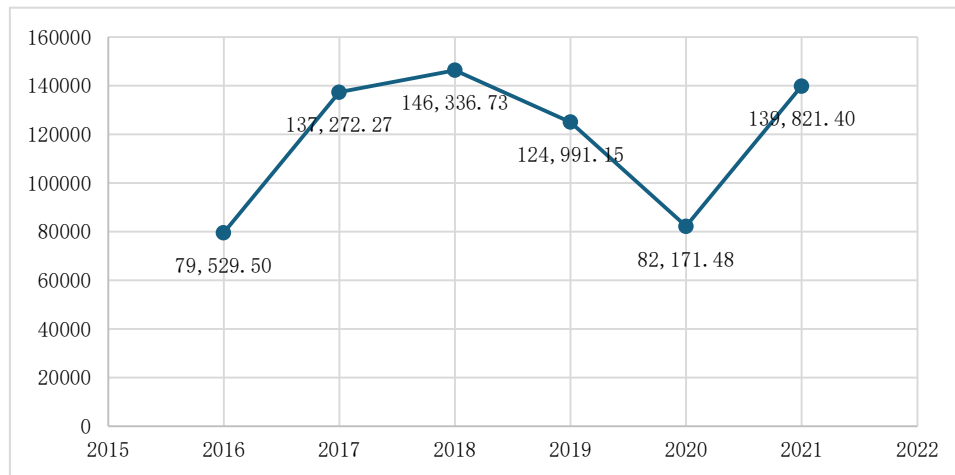


Figure 1. Foreign direct investments in Egypt

Source: Prepared by Researcher.

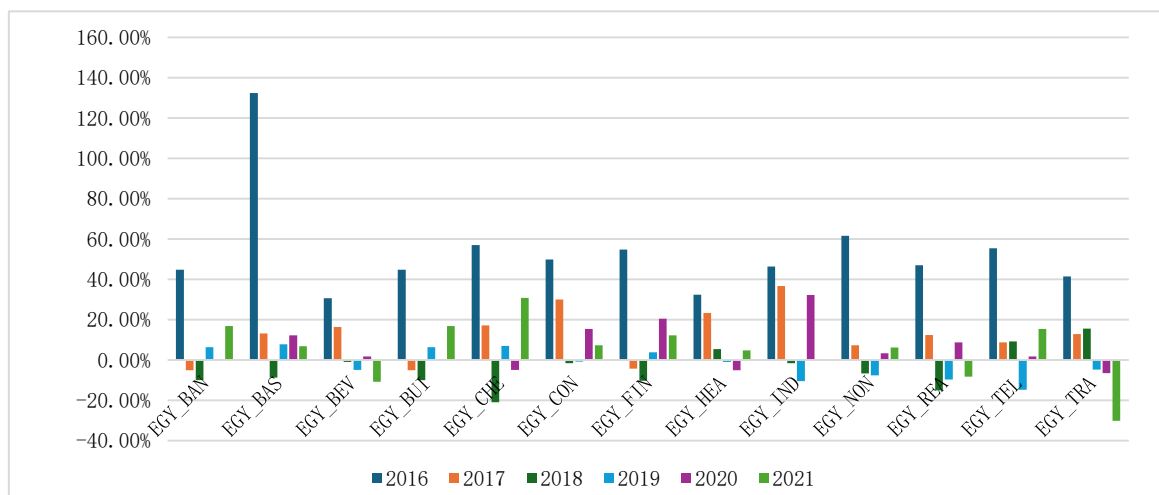


Figure 2. The performance of Egyptian stock market sectors

Source: Prepared by Researcher.

From the graph, can be explained development stages which reflect the extent of interest in foreign direct investment in Egypt. The Egyptian Stock Exchange has played a leading role among the regional stock exchanges in launching a variety of indicators designed to measure the performance of the market in line with the needs of investors. Graph 2 indicates the performance of each of the 13 sectors during 2016-2021. Hence, this study attempts to fill a gap in the exiting literature in Egypt by discussing over whether there is a significant effect of FDI on stock market sectors' performance for 13 sectors during 2007-2021. To measure this impact, the study considers determining some factors that materially influence sectors' performance, where it considers both the market characteristics and the macroeconomic variables. In short, this study tries to answer the following questions:

- Does FDI effect on performance of stock market sectors in Egypt?
- Do macroeconomics factors and market characteristics effect on performance of stock market sectors in Egypt?

Overall, this sample of this study includes 195 observations for 13 sectors and considers two groups of control variables, which included macroeconomic variables and market characteristics.

3. Related Literature and Research Hypotheses

Section 3 aims to present some of the previous review that has been conducted in two fields: a) foreign direct investments (FDI) and Application Difference in financial institutions; and b) impact of FDI on financial sector

and economic growth. Regarding the foreign direct investments (FDI) and application difference, some studies have been applied the relationship between FDI and financial or economic aspect to only one country (e.g., Boboye, 2014; Parvez & Azhar, 2019; Alsmadi & Oudat, 2019; Nwanji et al., 2020; Hafiluddin & Patunru, 2022; Ndlovu & Haabazoka, 2024).

On the other hand, others apply to emerging markets (e.g., Tsaourai & Makina, 2018) or 102 nations on four continents (e.g., Majeed et al., 2021) or 37 Asian countries (e.g., Tran & Huynh, 2022) or 99 nations (e.g., Khan et al., 2023) or GCC region (e.g., Alzarooni et al., 2024). Regarding the impact of FDI on financial sector and economic growth, some studies focus on examining the relation between FDI and financial sector and show that FDI enhance both financial performance and inclusion (Parvez & Azhar, 2019; Nwanji et al., 2020; Khan et al., 2023; Alzarooni et al., 2024).

Other studies revealed that FDI has a positive impact on financial development (Alsmadi & Oudat, 2019; Majeed et al., 2021; Tran & Huynh, 2022), or no strong relationship with company productivity (Hafiluddin and Patunru, 2022) or FDI and financial sector development has a negative impact on growth (Boboye, 2014). Obviously, these empirical findings are mixed. And these studies are briefly discussed as follows. In the regard of financial sector, Parvez and Azhar (2019) address what FDI impacts on financial performance for Indian Life Insurance Companies and examine whether is there difference in the tendency of FDI inflows, using a case study of IKM company during 2004-2014. They find that the performance of IKM firm was influenced by FDI and the overall trend of FDI in IKM company is sizeable over the study period.

Nwanji et al. (2020) indicate that FDI has a significant positive effect on the development and performance of 14 the listed deposit banks in Nigeria during 2010-2017. Conversely, they reveal that re-invested earnings and foreign equity capital have a significant adverse influence on bank performance. Khan et al. (2023) reveal that FDI has a significant and positive effect on financial inclusion for 99 nations during 2005-2016, but this impact differs across countries based on the level of financial inclusion. Alzarooni et al. (2024) explore whether FDI inflows affect bank stability under COVID-19 and the 2008 GFC for 6 countries in the GCC region during 2006-2021. They reveal that the GFC leads to a more negative relationship between FDI and bank stability than the epidemic crisis does, while the presence of Islamic banks mitigates negative effect of FDI during these crises.

As for the economic and production perspective, Alsmadi and Oudat (2019) examine the relationship between FDI and FD in Bahrain from 1978 to 2015. They affirm that there is a significant positive relation between FDI and FD in short and long run, while a significant adverse relation between Arab Spring and FD. They indicate that there is bidirectional causality relationship between FDI and financial development.

Additionally, Majeed et al. (2021) examine the impact of FDI on FD for 102 nations on four continents during 1990-2017. They show that FDI, trade openness, and government consumption have a significant positive influence on FD in Asia, Europe, and Latin America contrary in contrast to Africa. Similarly, Tran and Huynh (2022) conclude that FDI, trade openness, and population growth affect financial development (FD) positively, but inflation affect adversely it for 37 Asian nations during 2001-2020. Ndlovu and Haabazoka (2024) reveal that the inflow of FDI varied at a declining rate from 1996 to 2020 in Zambia. Generally, they find that FDI results in economic growth. They show that FDI has a significant negative impact on inflation, but not significant on interest, unemployment, and the national saving rate.

Nevertheless, Boboye (2014) shows that the interactions of FDI and financial sector development have positive significant impacts on economic growth of Nigeria in the short run during 1970-2011. FDI and financial sector development had separate negative significant impacts on growth. Boboye (2014) reveals there is a bi-directional causality relation between foreign direct investment, financial sector development and economic growth. While Hafiluddin and Patunru (2022) suggest that foreign investment has no significant effect on company productivity after the FDI reform during 2000-2015 in Indonesia.

Regarding the determinants of financial performance, most of the studies in the literature have revealed that there is positive or negative or not significant effects of macroeconomic according to countries and periods (Kiganda, 2014; Egbunike & Okerekeoti, 2018; Haider et al., 2018; Suseno, 2020; Arzova & Sahin, 2023; and Mitra, Gupta, & Gupta, 2023). As mentioned before, the results of the previous evidence are mixed. The current study considers the impact of macroeconomic factors on sectors' performance. This indicates the importance of the research field on investment and finance, clarifying the current research significance to explore the impact of FDI on stock market sectors' performance, considering economic changes. According to the literature review and problem statement discussed above, this study aims at testing the following hypotheses: a) H1: Egyptian stock market Sectors performance is significantly driven by FDI. B) H2: Egyptian stock market Sectors performance is significantly driven by macroeconomic factors. Hypothesis testing criteria:

HO1: There is no significant effect of FDI on Egyptian stock market sectors' performance.

HA1: There is a significant effect of FDI on Egyptian stock market sectors' performance.

HO2: There is no significant effect of macroeconomic factors on Egyptian stock market sectors' performance.

HA2: There is a significant effect of macroeconomic factors on Egyptian stock market sectors' performance.

This study explores the effect of FDI on Egyptian stock market sectors' performance over 15 years, compared to the other studies that focused on this relation with financial performance of companies or financial development for various period.

4. Research Methodology

4.1 Data Sources

The sample includes 195 observations from 13 sectors of Egyptian stock market, chosen as the most represented for the stock market sectors upon data availability from 2007 to 2021. To investigate the relationship between FDI and sectors' performance over the study period, this study employs panel data regression, Support Vector Regression and K-Nearest Neighbors. The data are obtained from several sources, including the World Development Indicators (WDI) database of the World Bank, the Central Bank of Egypt and the Egyptian Exchange (EGX).

The stock market sectors represent as follows: Banks, Basic Resources, Food, Beverages and Tobacco, Building Materials, Contracting & Construction Engineering, IT, Media & Communication Services, Health Care & Pharmaceuticals sector, Industrial Goods, Services & Automobiles, Non-bank financial services, Real Estate, Textile & Durables, Travel & Leisure, and Paper & Packaging.

4.2 Variable's Definition

This study uses FDI net inflows as a percentage of GDP as a proxy of FDI to assess its impact on the performance of Egyptian stock market sectors during the study period. The stock return is measured by calculating the change of sector index at the end of year. Besides, it selected four indicators identified from previous studies as control variables, which includes as follows: gross domestic product growth, inflation, real interest rate, and market capitalization of listed domestic companies. The following table shows description of the study variables.

Table 1. Description of the study variables

Variables	Code
Sector Return	Return
Foreign Direct Investment	FDI
Gross Domestic Product Growth	GDP_G
Inflation	INF
Real Interest Rate	REAL_INT
Market Capitalization of Listed Domestic Companies (% of GDP)	M_CAPIT

Source: Prepared by Researcher.

4.3 Research Models

In this section, an overview of the methodology that was employed will be given. The models were estimated using EViews and Statistica software.

4.3.1 Panel Generalized Method of Moments (GMM) Analysis

This study uses Panel Generalized Method of Moments (GMM) to assess the impact of FDI on Egyptian exchange sectors' performance. According to prior studies, stock market sectors' performance can be predicted as follows:

$$(\widehat{Return})_{it} = \alpha_0 + \beta_1 FDI_{it} + \beta_2 GDP_G_{it} + \beta_3 INF_{it} + \beta_4 REAL_INT_{it} + \beta_5 M_CAPIT_{it} + e_{it} \quad (1)$$

Where i indexes' sectors, t indicates years, and e_{it} is the error term, α is the intercept: β_j is the estimated regression coefficient of the variables; $j = 1, 2, 3, \dots, 5$.

4.3.2 Support Vector Regression (SVR) Model

The SVR is formed with 10-fold cross-validation and uses Radial Basis Function (RBF) kernel type. ϵ -SVR employs ϵ -insensitive loss function, in which errors smaller than ϵ will be omitted. It takes the following

formulation:

$$|y - f(x)|_{\varepsilon} \equiv \max \{0, |y - f(x)| - \varepsilon\} \quad (2)$$

The model mathematics of SVR is:

$$\text{Max}_{w, b, \varepsilon} \quad \frac{1}{2} \|w\|^2 + C \sum_{i=1}^n |y_i - f(x)|_{\varepsilon} \quad (3)$$

The support vectors and values of the solution determine the regression form, as follows:

$$f(x) = \sum_{i=1}^n \alpha_i K(x, x_i) + b \quad (4)$$

Regarding a-priori constants C, v the dual quadratic optimization problem is:

$$\text{max}_{\alpha, \alpha^*} \quad \sum_{i=1}^n (\alpha_i^* - \alpha_i) y_i - \frac{1}{2} \sum_{i,j=1}^n (\alpha_i^* - \alpha_i) (\alpha_j^* - \alpha_j) K(x_i, x_j) \quad (5)$$

4.3.3 K-Nearest Neighbors Model (k-NN)

The response value is calculated as a weighted sum of the responses of all the k neighbors, where the weight is in reverse proportionate to the distance from the input record. The Euclidean distance function is clarified as follows.

$$E(x, p) = \sqrt{\sum_a^m (x_a - p_a)^2} \quad (6)$$

Where x and p are the query point and a case from the set of examples, respectively, while m is the number of input variables. After selecting the value of k, predictions based on the KNN examples can be made; however, a prediction is the average over the outcomes for KNNs, as defined in eq. (6) (Al-Dosary et al., 2019).

$$y = \frac{1}{k} \sum_{i=1}^k y_i \quad (7)$$

Where y_i is the i^{th} example, and y is the prediction for the query point.

Accuracy metrics

Remarkably, the prediction performance is evaluated using the following statistical metrics: Root Mean Squared Error (RMSE) and Mean Absolute Error (MAE). To compare the methods used, this study calculated RMSE by using the following formula (Cao & Tay, 2001):

$$RMSE = \sqrt{\frac{1}{N} \sum_{i=1}^n (\gamma_i - \check{\gamma}_i)^2} \quad (8)$$

5. Empirical Results

5.1 Model Specification

According to descriptive statistic results as highlighted in Table 2, the mean of Return and FDI are 0.033497 and 70140.20 respectively. The standard deviation of Return is 0.218051 with minimum and maximum values of -0.452836 and 1.324852 respectively. The standard deviation of FDI is 45250.37 ranging from 12304.18 to 146336.7. While the GDP_G has a mean value of around 4.255013 with minimum value of 1.764572 and maximum value of 7.156284. Averages of INF, M_CAPITAL and REAL_INT are 11.65900, 28.97962 and 0.793967 respectively. REAL_INT ranges from -6.262720 to 6.922011, while M_CAPITAL range is 96.75038 and INF range is 24.461677.

Table 2. Descriptive statistics

Variable	N	Mean	Median	Minimum	Maximum	Std. Dev.	Skewness	Kurtosis	Jarque-Bera
FDI	195	70140.20	53320.42	12304.18	146336.7	45250.37	0.512075	1.809196	20.04353
GDP_G	195	4.255013	4.346643	1.764572	7.156284	1.595441	0.250692	2.266111	6.418581
INF	195	11.65900	10.07022	5.044933	29.50661	5.813947	1.815430	6.348035	198.1890
M_CAPITAL	195	28.97962	20.69992	10.02372	106.7741	24.31324	2.181982	7.227059	299.9117
REAL_INT	195	0.793967	0.710036	-6.262720	6.922011	3.292245	-0.248455	2.852451	2.183107
Return	195	0.033497	0.003638	-0.452836	1.324852	0.218051	1.352883	8.686750	322.2399

Source: Outputs of data processing using Eviews 12.

Table 3. Correlation matrix

Variable	FDI	GDP_G	INF	M_CAPIT	REAL_INT	Return
FDI	1.000000					
GDP_G	0.256293***	1.000000				
INF	0.264501***	0.297049***	1.000000			
M_CAPIT	-0.235731***	0.620435***	0.039161	1.000000		
REAL_INT	0.077397	0.021773	-0.374236***	-0.190075***	1.000000	
Return	0.149276**	-0.069035	0.029989	-0.092470	0.401480***	1.000000

Source: Outputs of data processing using Eviews 12.

Note. For significant correlation indication, * $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$.

Table 3 presents the correlation matrix for the current research variables. As displayed in the table a significant positive association occurs between FDI and Return at $p < 0.05$ and a negative correlation between FDI and M_CAPIT at $p < 0.01$ significance level besides a positive linkage occurs between FDI and both GDP_G and INF at $p < 0.01$ of significance level. In addition, a positive relationship emerges between GDP_G and both INF and M_CAPIT at $p < 0.01$ level of significance while no significant association exists between GDP_G and REAL_INT. There is a negative relation between REAL_INT and both INF and M_CAPIT at a significance level of $p < 0.01$, while a significant positive relationship occurs between Return and REAL_INT at $p < 0.01$. Additionally, this study assessed the variance inflation factors and reported the highest observed value of 3.12 which is below the conventional cut off 10.0, hence this indicates there was no multicollinearity.

5.2 FDI and Stock Market Sectors' Performance Empirical Results

Table 4 presents the results of the panel Generalized Method of Moments (GMM) of this study, as follows:

Table 4. FDI and stock market sectors' performance in Egypt

	Coeff	Std. Error	t-Statistic
C	-0.035386	0.044247	-0.799742
FDI	9.91E-07	3.67E-07	2.701515***
GDP_G	-0.056553	0.013952	-4.053404***
INF	0.011167	0.002847	3.922005***
M_CAPIT	0.002766	0.000891	3.102401***
REAL_INT	0.037396	0.004855	7.702793***
R-squared	0.266352		
Adjusted R-squared	0.246943		
S.E. of regression	0.189222		

Note. ***, ** and * reflect significant at 1, 5 and 10% levels, respectively.

The outcomes show the coefficient of FDI is positive and statistically significant ($P < 0.01$) with Return, hence this result does support the hypothesis, which indicates that FDI has positively affects sectors' performance. Further, INF, M_CAPIT and REAL_INT are positive and statistically significant with Return, while GDP_G is negative and significant with Return, suggesting that GDP_G has inversely affected sectors' performance. Thus, hypothesis 2 is supported, showing that there is an impact of macroeconomics factors on sectors' performance in Egypt. In this context, hypotheses 1 and 2 are supported.

5.3 Results of SVMs and k-NN in Regression

The methods were implemented using the statistica software. The results reveal that the model based on the k-NN approach performs better in prediction, compared to other methods.

Table 5. The comparison of empirical results

	GMM	SVR	k-NN
Dependent variable		Return	
Root MSE	0.186288	0.12937	0.12879
Abs. error mean (MAE)	---	0.091242	0.100485
R-squared	0.266	0.653	0.722

Source: Outputs of data processing using Statistica software.

The prediction obtained from GMM has an RMSE 0.1862, while the prediction obtained from the SVR and k-NN have an RMSE 0.1293 and 0.1287, respectively. The smaller RMSE value means the prediction obtained from the k-NN model fits the actual data better than the GMM and SVR models. Hence, the k-NN approach produces a better-fitting model compared to other models.

6. Conclusion and Recommendation

This study aims to investigate the impact of FDI, represented by net foreign direct investment, considering economic changes on Egyptian stock market sectors' performance. This has been applied on 13 sectors on an annual basis during 2007-2021. The stock return is measured by calculating the change in sectoral indices. The results show a significant positive effect of FDI on sectors' performance, indicating that FDI may increase the return of Egyptian exchange sectors. This study also determined macroeconomic factors and market characteristics, such as GDP growth, inflation, real interest rate, and market capitalization, as determinants of sectors' performance.

The findings reveal that the K-Nearest Neighbors (k-NN) approach performed better in prediction compared to the panel GMM and Support Vector Regression (SVR) models, highlighting the potential of machine learning techniques in analyzing financial data. This study contributes to the previous literature by providing empirical evidence on the impact of FDI on sectors performance, employing machine learning techniques and comparing the results to identify the best approach in prediction.

These empirical results provide new insights for policymakers and investors, presenting several practical implications for crafting policies that are adaptive to economic conditions and contributing to more effective decision-making related to investment policies in sectors and how to attract and manage foreign investment. However, the study has limitations, including the potential for unobserved heterogeneity across sectors, as well as the exclusion of other potential moderating factors. Future studies could check the impact of decision of investments on the financial performance under unstable political and health conditions or focus on the relationship between FDI and financial inclusion under digital economy.

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