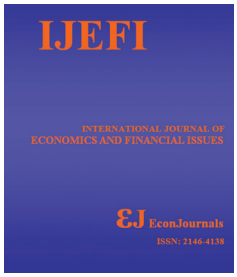

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A Vector Autoregression Analysis of Corruption, Unemployment, and Foreign Direct Investment Outflows in Sudan

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ABSTRACT

This study examines the dynamic interrelationships between corruption, unemployment, and foreign direct investment FDI outflows in Sudan using a vector autoregression (VAR) model. The objective is to explore how corruption influences both unemployment and FDI outflows, and the combined impact of these variables on Sudan's economic performance. The importance of this research lies in its potential to address economic policy and institutional reforms in Sudan, a country marked by ongoing political instability and economic challenges. The study draws upon existing literature that shows how corruption increases transaction costs, deters foreign investment, and misallocates public resources, thus contributing to higher unemployment. The VAR model is applied using time-series data from 2003 to 2023, focusing on key variables such as the corruption perceptions index (CPI), unemployment rates, and FDI outflows. The results reveal that corruption significantly contributes to FDI outflows and has a long-term negative impact on unemployment. The study emphasises the critical role of governance in shaping both investment behaviour and labour market outcomes. The findings advocate for stronger institutional frameworks and anti-corruption measures to create a more attractive business environment, reduce unemployment, and prevent further capital flight. These insights offer valuable guidance for policymakers and international organisations seeking to promote sustainable economic development in Sudan.

Keywords: Corruption, Unemployment, Foreign Direct Investment Outflows, Vector Autoregression
JEL Classifications: D73, F21, J64, O55

1. INTRODUCTION

The relationship between corruption, unemployment, and foreign direct investment FDI is crucial for understanding the economic development challenges faced by many developing countries. Among these, Sudan stands out due to its prolonged economic instability, which is intricately tied to governance issues such as corruption. Corruption, often seen as a barrier to economic progress, and has far-reaching consequences on various aspects of a country's economy, including its attractiveness for foreign investment and the efficiency of its labour market. The study used a vector autoregression (VAR) model to investigate the complex interrelationships between corruption perception, unemployment, and FDI outflows in Sudan, aiming to shed light on how these dynamics interact over time and influence the country's economic trajectory.

The importance of this study is to offer guidelines for economic policy and institutional reforms in Sudan. By focusing on the interaction between corruption, unemployment, and FDI outflows, aiming to enhance the understanding of these variables' roles in shaping Sudan's economic environment. Specifically, it seeks to

determine the extent to which corruption perception impacts both unemployment rates and FDI outflows, and how these elements collectively influence Sudan's economic performance. Moreover, the study's findings will contribute to broader discussions on the role of governance in shaping economic outcomes in developing countries, particularly in regions like Sub-Saharan Africa.

This research draws upon a substantial body of literature that examines the relationship between corruption and unemployment. Numerous studies have highlighted the negative effects of corruption on economic growth and labour markets. Gupta et al. (2002) argue that corruption diverts public funds away from essential services, which hampers economic development and reduces job creation. Similarly, Tanzi and Davoodi (2000) suggest that corruption misallocates resources, leading to inefficiencies in public services and infrastructure, which directly affect employment opportunities. The evidence from Borensztein et al. (1998) and Carkovic and Levine (2002) further supports this view, as they show that countries with higher levels of corruption experience slower job creation, particularly in sectors that require substantial public investment.

The relationship between corruption and FDI outflows has also been extensively studied, with a consensus emerging that corruption significantly discourages foreign investment. Wei (2000) is one of the earliest scholars to document how corruption raises transaction costs, creating a risky business environment that deters foreign investors. Similarly, Mauro (1995) argues that corruption weakens the institutional environment, reducing the efficiency of public investments and thereby decreasing the country's attractiveness to foreign investors. Habib and Zurawicki (2002) find that countries with lower corruption levels tend to attract more foreign direct investment, as they provide a more predictable and transparent business environment. Further empirical evidence from Adebayo and Akinboade (2014) suggests that in African economies, corruption exacerbates political instability, which in turn increases FDI outflows. These findings underline the critical role of governance in shaping investment patterns, particularly in unstable economic environments like Sudan's.

To explore these relationships in the Sudanese context, this study applies the vector autoregression (VAR) methodology, a powerful tool in analysing the interdependencies among economic variables. VAR models have been widely used to study the effects of corruption, FDI, and unemployment in other emerging economies. Studies by Apergis and Payne (2012) and Apergis et al. (2014) have successfully applied VAR to explore how corruption influences FDI and economic growth. These studies have shown that corruption impedes investment and economic development, with long-term consequences on employment and growth. Similarly, using VAR models, Aziz and Hossain (2015) have examined the effects of corruption on FDI inflows in developing countries, revealing significant negative relationships. These previous studies confirm the suitability of VAR models for examining the relationships among corruption, unemployment, and FDIO in Sudan, a country facing similar governance and economic challenges.

In Sudan, corruption has been a persistent issue, and its impact on economic development is well-documented. Over the past two decades, Sudan has experienced significant political instability, with corruption being one of the main factors hindering its economic development. According to Transparency International's corruption perceptions index (CPI), Sudan has consistently ranked poorly, reflecting the widespread corruption that affects its public sector. This environment has led to reduced investor confidence, as foreign investors are often deterred by the perceived risks and high transaction costs associated with corruption. Concurrently, Sudan's unemployment rate remains a significant challenge, exacerbated by a lack of foreign investment and inefficient public spending. Recent trends indicate a growing concern over these issues, with unemployment rates rising as FDI outflows increase due to political instability and corruption.

This study aims to confirm the extent to which corruption impacts unemployment and FDI outflows by answering the critical question: What is the relationship between corruption, unemployment, and FDI outflows in Sudan? The use of a VAR model allows for an in-depth analysis of how these variables interact over time and how past events influence current economic outcomes. By doing so, this research will provide a comprehensive understanding of the economic dynamics at play and offer policy recommendations for mitigating the effects of corruption and fostering a more conducive environment for investment and job creation.

The research is structured as follows: Section 1 introduces the study, explaining the research objectives, significance, and research question. Section 2 provides a comprehensive literature review on the relationship between corruption, unemployment, and FDI outflows, highlighting key studies and theoretical frameworks. Section 3 outlines the methodology, describing the data sources, empirical model, and the application of the VAR model. Section 4 presents the results and discusses the findings in light of the existing literature. Finally, Section 5 concludes the study, offering policy implications based on the research findings.

In conclusion, this study provides a timely and relevant examination of the relationship between corruption, unemployment, and FDI outflows in Sudan. By using a rigorous econometric approach and drawing on a substantial body of literature, the study offers new insights into the economic challenges facing Sudan and highlights the critical role of governance reforms in addressing these issues. The findings of this study could serve as a foundation for policymakers and international organisations aiming to promote sustainable economic development in Sudan and other countries facing similar governance challenges.

2. LITERATURE REVIEW

The relationship between corruption, unemployment, and foreign direct investment (FDI) has been a subject of significant debate in economic research, particularly in the context of developing countries. This literature review synthesises findings from various studies, providing insights into how corruption and unemployment influence FDI flows and the implications of such dynamics for Sudan's economic development. A vector autoregression

(VAR) model is particularly useful in this analysis as it allows for understanding the interdependencies among these variables over time.

Corruption is widely recognised as a major barrier to economic development, with numerous studies highlighting its detrimental effects on FDI. According to Wei (2000), corruption raises the cost of doing business, creating an unfavourable environment for foreign investors. He argues that when corruption levels are high, foreign investors are less likely to commit capital due to increased risks, higher transaction costs, and a lack of transparency. Similarly, Mauro (1995) asserts that corruption reduces the efficiency of public spending, which in turn limits the ability of the government to invest in infrastructure, a key factor in attracting foreign investment. These findings suggest that a reduction in corruption could potentially increase FDI inflows by improving the investment climate.

Conversely, the impact of corruption on unemployment has been a topic of much scholarly interest. Some researchers argue that corruption leads to higher unemployment, as it diverts public funds away from essential services and infrastructure projects (Gupta et al., 2002). This diversion results in lower levels of economic activity and fewer job opportunities. For instance, an increase in corruption often means that public resources, which could otherwise be used to create jobs, are misallocated. However, other studies have suggested that corruption can sometimes reduce unemployment by enabling the establishment of informal channels that facilitate business operations, albeit at the cost of public integrity (Tanzi and Davoodi, 2000). The interaction between corruption and unemployment is thus complex and requires careful consideration when analysing its impact on developing economies like Sudan.

Unemployment, as an economic variable, plays a crucial role in determining the attractiveness of an economy to foreign investors. Studies by Borensztein et al. (1998) and Carkovic and Levine (2002) suggest that high levels of unemployment can discourage foreign direct investment. Unemployment signals an economy's inefficiency, suggesting that labour markets may be rigid, and that there may be skills mismatches. Investors may perceive high unemployment as a sign of potential social instability, which could further deter FDI. Conversely, other studies have suggested that high unemployment could be indicative of a large, untapped labour force, which could be seen as an opportunity by foreign investors looking for low-cost labour (Feenstra et al., 2001). Thus, the relationship between unemployment and FDI is not straightforward and requires a nuanced approach.

Foreign direct investment (FDI) is often considered a catalyst for economic growth, as it brings in capital, technology, and managerial expertise. Several studies have confirmed that FDI can positively impact economic growth, particularly in developing countries (Lipsey, 2001). In the case of Sudan, FDI could play a critical role in addressing its economic challenges. However, the inflow of FDI depends on several factors, including the level of corruption, the stability of the political environment, and the availability of a skilled workforce. According to Habib and Zurawicki (2002), FDI is sensitive to corruption, and countries with lower corruption levels tend to attract more investment. This underscores the importance of establishing sound institutional frameworks to mitigate corruption and encourage foreign investment.

A growing body of literature has employed vector autoregression (VAR) models to explore the interrelationships between economic variables like corruption, unemployment, and FDI. A study by Apergis and Payne (2012) used a VAR model to examine the relationship between FDI, economic growth, and corruption in emerging markets. Their findings suggest that while corruption negatively impacts FDI, the long-term effects of corruption on economic growth and employment are more complex, as the relationship varies across different economic contexts. Similarly, the use of VAR models in the Sudanese context could provide valuable insights into how these three variables interact and influence each other.

The impact of corruption on FDI and unemployment has also been analysed from the perspective of institutional quality. According to North (1990), the strength of institutions plays a vital role in determining a country's ability to attract FDI. Countries with weak institutions tend to experience higher levels of corruption, which in turn negatively affects their FDI inflows and employment rates. In Sudan, the quality of governance and the rule of law are critical factors influencing both foreign investment and unemployment levels. If Sudan can strengthen its institutions, it could potentially reduce corruption and create a more favourable environment for FDI, which would have positive effects on the labour market.

The interaction between corruption and FDI in the African context has been the subject of several studies. Adebayo and Akinboade (2014) investigated the relationship between corruption and FDI in African economies, finding that corruption has a statistically significant negative impact on foreign investment. This is particularly true in countries with unstable political environments and weak institutional frameworks. For Sudan, which has faced political instability and economic challenges in recent decades, addressing corruption is a necessary step towards creating a more attractive environment for foreign investors.

A related body of research has focused on the role of economic policies in mitigating the adverse effects of corruption. Studies by Barro (1991) and Sachs and Warner (1995) suggest that sound economic policies can help mitigate the effects of corruption on FDI and employment. For Sudan, implementing pro-business reforms, improving the legal framework, and reducing bureaucratic inefficiencies could attract more FDI, thereby improving employment prospects. However, these reforms must be accompanied by a commitment to transparency and anti-corruption measures to ensure that the benefits of FDI translate into meaningful economic growth and job creation.

In conclusion, the literature reveals a complex and multifaceted relationship between corruption, unemployment, and FDI. Corruption generally acts as a deterrent to FDI, as it raises the cost of doing business and reduces the effectiveness of public

investment. Unemployment, on the other hand, can either encourage or discourage FDI depending on the underlying economic conditions. The use of VAR models provides a valuable tool for understanding the dynamic relationships between these variables. For Sudan, addressing corruption and improving institutional quality could play a crucial role in attracting more foreign investment and reducing unemployment. Further empirical research using VAR models is necessary to explore the specific dynamics in the Sudanese context and to inform policy recommendations aimed at fostering economic growth and development.

3. METHODOLOGY

3.1. Data Sources and Variables Description

This study aims to explore the interrelationship between corruption, unemployment, and foreign direct investment outflows (FDIO) in Sudan over the period from 2003 to 2023. The variables included in the analysis are defined below, and the data sources for these variables are listed in Table 1.

3.1.1. Corruption perception index (CPI)

The corruption perception index (CPI) score is used as a proxy for the level of corruption in Sudan. CPI is compiled annually by transparency international (TI), based on expert assessments and surveys from various institutions that evaluate corruption levels in the public sector (Transparency International, 2023). Higher values indicate lower corruption levels.

3.1.2. Unemployment (UNEM)

Unemployment is measured as the percentage of the labour force that is unemployed and actively seeking work. This data is sourced from the central bureau of statistics (CBS) of Sudan, which compiles annual labour force surveys (Central Bureau of Statistics, 2023).

3.1.3. Foreign direct investment outflows (FDIO)

Foreign direct investment (FDI) is measured as the outflow of FDI as a percentage of GDP. The World Bank (WB) provides data on FDI outflows, reflecting the amount of capital invested abroad by Sudanese entities and its potential impact on the domestic economy (World Bank, 2023).

Table 1: Provides a summary of the variables used in this study and their respective data sources

Variable	Notation	Description	Data source
Corruption perception index score	CPI	Corruption perception score (higher=less corruption)	Transparency International (TI)
Unemployment	UNEM	Unemployment rate (%)	Central Bureau of Statistics (CBS)
Foreign direct investment outflow	FDIO	FDI Outflow as % of GDP	World Bank (WB)

Source: Authors' contribution

Table 2: ADF test summary for all variables (level)

Variable	ADF test statistic	P-value	Critical value (1%)	Critical value (5%)	Critical value (10%)	Stationary (P<0.05)
CPI	−0.534962	0.8645	−3.808546	−3.020686	−2.650413	No
UNEM	−0.441348	0.8837	−3.808546	−3.020686	−2.650413	No
FDIO	−3.203628	0.0349	−3.808546	−3.020686	−2.650413	Yes

Source: Authors' estimations based on EViews

Table 3: ADF test summary for all variables (first differences)

Variable	ADF test statistic	P-value	Critical value (1%)	Critical value (5%)	Critical value (10%)	Stationary (P<0.05)
D (CPI)	−5.007497	0.0009	−3.831511	−3.029970	−2.655194	Yes
D (UNEM)	−5.516454	0.0003	−3.831511	−3.029970	−2.655194	Yes
D (FDIO)	−6.945932	0.0000	−3.831511	−3.029970	−2.655194	Yes

Source: Authors' estimations based on Eviews

Table 4: VAR lag order selection criteria results

Sample size	Lag	LogL	LR	FPE	AIC	SC	HQ
19 observations	0	−135.8881	NA	448.7484*	14.61980*	14.76892*	14.64504*
	1	−131.0791	7.593110	710.8813	15.06096	15.65745	15.16191
18 observations	0	−129.9889	NA	524.9249*	14.77654*	14.92494*	14.79700*
	1	−125.2817	7.322277	864.8136	15.25352	15.84710	15.33537
	2	−121.8079	4.245718	1778.501	15.86755	16.90632	16.01078
17 observations	0	−121.3564	NA	453.4734*	14.63016*	14.77720*	14.64478*
	1	−116.1965	7.891482	731.6261	15.08195	15.67010	15.14041
	2	−111.3596	5.690506	1358.187	15.57172	16.60098	15.67403
	3	−105.8360	4.548832	2943.772	15.98071	17.45109	16.12687
16 observations	0	−109.3465	NA	252.1878	14.04332	14.18818	14.05073
	1	−104.8862	6.690557	459.2594	14.61077	15.19021	14.64044
	2	−100.6469	4.769145	974.6147	15.20586	16.21989	15.25779
	3	−96.35487	3.219036	2778.700	15.79436	17.24296	15.86854
	4	−37.50908	22.06717*	19.70860*	9.563636*	11.44682*	9.660070*

Source: Authors' estimations based on EViews

Table 5: Significant lags and coefficients

Equation	Variable (lag)	Coefficient	t-statistic	Significance
CPI equation	CPI (−1)	−0.492306	−0.91980	Not significant
	CPI (−2)	−0.661782	−1.11869	Not significant
	CPI (−4)	−0.584346	−0.81200	Not significant
	FDIO (−1)	0.076446	0.06710	Not significant
	Constant (C)	5.799572	1.36379	Not significant
UNEM equation	CPI (−4)	0.789339	3.95818	Highly significant
	FDIO (−3)	0.719115	1.62169	Not significant
	UNEM (−1)	0.433290	1.35451	Not significant
	Constant (C)	−1.225188	−1.03967	Not significant
FDIO equation	FDIO (−1)	−1.702414	−2.52168	Significant
	FDIO (−4)	−2.019750	−1.88312	Borderline significant
	CPI (−3)	0.617821	0.83299	Not significant
	UNEM (−3)	0.977286	1.43220	Not significant
	Constant (C)	−1.698285	−0.67395	Not significant

Source: Authors' estimations based on Eviews

Table 6: Model fit and diagnostics

Metric	CPI score	FDI outflow	Unemployment
R-squared	0.511	0.771	0.879
Adjusted R-squared	−1.443	−0.145	0.396
Sum of squared residuals	71.477	25.098	5.489
Log Likelihood	−34.677	−26.305	−14.144
Akaike AIC	5.960	4.913	3.393
Schwarz SC	6.587	5.541	4.021

Source: Authors' estimations based on Eviews

3.1.4. Research period

The study covers data from 2003 to 2023. The year 2003 marks the point at which Sudan was included in Transparency International's Corruption Perceptions Index, making it the starting point for the analysis. The dataset ends in 2023, as this is the most recent year for which the variables are available.

3.2. Estimation Technique

To examine the relationships among corruption, unemployment, and foreign direct investment in Sudan, a vector autoregression (VAR) model is employed. The VAR approach is particularly suitable for modelling the interdependencies among multiple time-series variables without requiring strong a priori assumptions about the direction of causality (Sims, 1980). It allows for the simultaneous analysis of the impact of past values of each variable on the others.

The VAR model is capable for capturing dynamic relationships among corruption (CPI), unemployment (UNEM), and (FDIO) by considering the lagged values of each variable. This technique enables us to analyse both the short-term and long-term effects of one variable on the others while accounting for their mutual interdependence.

The key steps in the estimation process are as follows:

i. Stationarity testing: Before applying the VAR model, we will test the stationarity of the time-series data using the Augmented Dickey-Fuller (ADF) test. If any of the variables are found to be non-stationary, they will be differenced to achieve stationarity.
ii. Lag length selection: The optimal lag length for the VAR model will be determined using information criteria, such as the Akaike information criterion (AIC) and the Schwarz information criterion (SC). These criteria help in selecting the appropriate lag length that minimises model specification errors.
iii. Estimation of VAR model: Once the stationarity and optimal lag length are determined, the VAR model will be estimated to analyse the relationships between the three variables. The model will help identify both the short-term and long-term interactions between corruption, unemployment, and FDIO.

3.3. Empirical Model Specification

The empirical model used in this study is a VAR system with three variables: CPI (corruption perception index), UNEM (unemployment), and FDIO (foreign direct investment outflow as a percentage of GDP). The general specification of the VAR model is as follows:

$$CPI_t = \alpha_1 + \sum_{i-1}^{p} \beta_{1i} CPI_{t-i} + \sum_{i-1}^{p} \gamma_{1i} UNEM_{t-i} + \sum_{i-1}^{p} \delta_{1i} FDIO_{t-i} + \epsilon_{1t} \quad (1)$$

$$UNEM_t = \alpha_2 + \sum_{i-1}^{p} \beta_{2i} CPI_{t-i} + \sum_{i-1}^{p} \gamma_{2i} UNEM_{t-i} + \sum_{i-1}^{p} \delta_{2i} FDIO_{t-i} + \epsilon_{2t} \quad (2)$$

$$FDIO_t = \alpha_3 + \sum_{i-1}^{p} \beta_{3i} CPI_{t-i} + \sum_{i-1}^{p} \gamma_{3i} UNEM_{t-i} + \sum_{i-1}^{p} \delta_{3i} FDIO_{t-i} + \epsilon_{3t} \quad (3)$$

Where:

- CPI_t, $UNEM_t$, and $FDIO_t$ are the values of the Corruption Perception Index, unemployment rate, and FDI outflow as a percentage of GDP at time t, respectively.
- p is the lag length selected based on the optimal lag criteria.
- α_1, α_2, and α_3 are constant terms for each equation.
- β, γ, and δ represent the coefficients for the lagged values of the respective variables.
- ϵ_{1t}, ϵ_{2t}, and ϵ_{3t} are the error terms for each equation.

Table 7: Granger causality results

Dependent variable	Excluded variable	Chi-square (χ^2)	Degrees of freedom (df)	P-value	Conclusion
CPI	FDIO	0.9108	4	0.9230	No granger causality
	UNEM	1.1394	4	0.8880	No granger causality
	All	2.1655	8	0.9755	No joint granger causality
UNEM	CPI	17.0270	4	0.0019	Granger causality exists
	FDIO	10.0043	4	0.0404	Granger causality exists
	All	20.1005	8	0.0100	Joint granger causality exists
FDIO	FDIO	3.2241	4	0.5211	No granger causality
	UNEM	2.4577	4	0.6522	No granger causality
	All	4.5127	8	0.8082	No joint granger causality

Source: Authors' estimations based on Eviews

Table 8: Variance decomposition of CPI

Period	Standard error (S.E.)	CPI (%)	FDIO (%)	UNEM (%)
1	4.881172	100.0000	0.0000	0.0000
2	6.180855	97.5451	2.3985	0.0564
3	6.742440	92.0049	7.9306	0.0644
4	7.934745	88.6444	11.2825	0.0730
5	8.562554	80.7858	19.1501	0.0641
6	10.72238	83.1656	16.7709	0.0635
7	11.68123	85.3830	14.5594	0.0576
8	14.98272	70.1267	29.8287	0.0446
9	22.58904	31.5698	68.4106	0.0197
10	40.63591	23.3138	76.6729	0.0133

Source: Authors' estimations based on Eviews

Table 9: Variance decomposition of FDI outflow

Period	Standard error (S.E.)	CPI (%)	UNEM (%)	FDIO (%)
1	2.892405	17.1844	0.0000	82.8156
2	6.078216	16.5025	0.0171	83.4804
3	10.00926	20.3939	0.0071	79.5990
4	18.28887	47.1827	0.0274	52.7898
5	25.15949	62.8285	0.0300	37.1415
6	32.99841	77.7894	0.0384	22.1722
7	43.21261	59.0260	0.0301	40.9440
8	73.20069	20.7353	0.0105	79.2542
9	137.1205	18.5805	0.0090	81.4105
10	234.2116	34.7123	0.0168	65.2710

Source: Authors' estimations based on Eviews

Table 10: Variance decomposition of unemployment

Period	Standard error (S.E.)	CPI (%)	UNEM (%)	FDIO (%)
1	1.352633	69.8167	1.0959	29.0874
2	1.576087	74.6196	0.9587	24.4216
3	1.940065	80.3392	0.7823	18.8785
4	2.546933	84.4678	0.5716	14.9607
5	4.242548	93.6176	0.2379	6.1445
6	4.243529	93.5927	0.2432	6.1641
7	4.464221	88.3048	0.2351	11.4601
8	4.493783	87.8966	0.2334	11.8701
9	4.769259	86.7249	0.2073	13.0678
10	5.285989	79.2231	0.1849	20.5920

Source: Authors' estimations based on Eviews

This model specification allows for an examination of the direct and indirect effects of corruption on unemployment and FDI outflow, and vice versa. By using a VAR model, we can also test for the causality among the variables and provide insights into the policy implications of these relationships.

Table 11: Response of CPI score

Period	CPI	UNEM	FDIO
1	4.8812	0.0000	0.0000
2	−3.6660	−0.1467	0.9572
3	−2.1356	−0.0881	−1.6398
4	−3.7396	−0.1292	1.8703
5	1.8491	−0.0318	−2.6338
6	−6.0320	−0.1614	2.2893
7	4.5707	0.0747	0.7649
8	−6.3965	−0.1468	−6.8625
9	−1.9151	−0.0112	16.7963
10	14.9628	0.3445	−30.2821

Source: Authors' estimations based on Eviews

Table 12: Response of FDIO

Period	CPI	UNEM	FDIO
1	−1.1990	0.0000	2.6322
2	2.1585	0.0794	−4.8901
3	−3.7861	−0.0281	6.9932
4	11.7212	0.2909	−9.8400
5	−15.4883	−0.3131	7.6507
6	21.1977	0.4782	2.5151
7	−15.9739	−0.3784	−22.8720
8	−2.9765	−0.0446	59.0097
9	48.8103	1.0602	−105.1671
10	−124.6913	−2.7411	143.1699

Source: Authors' estimations based on Eviews

Table 13: Response of unemployment

Period	CPI	UNEM	FDIO
1	1.1302	0.1416	−0.7295
2	0.7591	0.0614	−0.2729
3	1.0818	0.0750	0.3224
4	1.5670	0.0874	0.5098
5	3.3721	0.0758	0.3681
6	0.0574	0.0314	0.0636
7	0.8630	0.0553	−1.0835
8	0.3891	0.0165	0.3364
9	1.4058	0.0046	−0.7585
10	−1.5524	−0.0671	1.6677

Source: Authors' estimations based on Eviews

4. RESULTS AND DISCUSSION

4.1. Augmented Dickey-Fuller (ADF) Test Results

The ADF test results at the level form indicate mixed stationarity among the variables. CPI score series test statistic of −0.5349 is higher than the critical values at all significance levels, and the P = 0.8645 far exceeds the 0.05 threshold. This suggests that the CPI

Table 14: VAR residual normality test results

Component	Skewness	Chi-square	df	P-value	Kurtosis	Chi-square	df	P-value	Jarque-bera	df	P-value
1	0.7861	1.6478	1	0.1993	3.1614	0.0174	1	0.8951	1.6652	2	0.4349
2	0.9768	2.5445	1	0.1107	4.4239	1.3517	1	0.2450	3.8962	2	0.1425
3	0.6938	1.2836	1	0.2572	3.5663	0.2138	1	0.6438	1.4974	2	0.4730
Joint	N/A	5.4759	3	0.1401	N/A	1.5829	3	0.6633	7.0588	6	0.3154

Source: Authors' estimations based on Eviews

Table 15: Adjusted VAR residual portmanteau test for autocorrelations

Lags	Q-Stat	Prob.*	Adj Q-Stat	Prob.*	df
1	16.44350	0.2572	17.53973	0.1993	3
2	21.50855	0.2450	23.32836	0.1107	6
3	25.32981	0.6438	28.03145	0.4349	9
4	29.15974	0.4730	33.13803	0.3154	12

Source: Authors' estimations based on Eviews

Table 16: List of acronyms

Acronym	Full form
ADF	Augmented dickey-fuller
Adj Q-Stat	Adjusted Q-statistic
AIC	Akaike information criterion
CBS	Central bureau of statistics
CPI	Corruption perception index
DF	Degrees of freedom
FDIO	Foreign direct investment outflow
FPE	Final prediction error
GDP	Gross domestic product
HQ	Hannan-quinn information criterion
IRF	Impulse response functions
LogL	Log-Likelihood
LR	Likelihood ratio
Prob	Probability
Q-Stat	Ljung-Box Q-statistic
SC	Schwarz information criterion
TI	Transparency international
UNEM	Unemployment rate
VAR	Vector autoregression
WB	World Bank

Source: Authors' contribution

score is non-stationary at its level, meaning its statistical properties, such as mean and variance, vary over time (Table 2). Similarly, the unemployment series is non-stationary, with a test statistic of −0.4413 and a P = 0.8837, indicating that the null hypothesis of a unit root cannot be rejected.

In contrast, the FDI outflow series is stationary at its level, as its test statistic of −3.2036 is lower than the critical values at the 5% and 10% significance levels, and the P = 0.0349 is below 0.05. This finding implies that the mean and variance of FDI outflow remain consistent over time. The non-stationarity of the CPI score and unemployment highlights the need for differencing these variables to achieve stationarity before including them in the time-series VAR model. Ensuring stationarity is crucial for producing reliable and meaningful results in time-series analysis.

The Augmented Dickey-Fuller (ADF) test results for the first differences of the variables confirm their stationarity, which is essential for reliable time-series modelling. The first difference for the CPI score series, with a test statistic of −5.0075, is lower than the critical values at all significance levels (1%, 5%, and 10%), and the P = 0.0009 is well below the threshold of 0.05, which indicates that the CPI score is stationary at the first difference, with no unit root present. Similarly, the FDI outflow series exhibits strong stationarity, with an ADF test statistic of −6.9459 and a P = 0.0000, indicating a clear rejection of the null hypothesis of a unit root at the first difference.

The results for the unemployment series at first difference shows stationarity, with an ADF test statistic of −5.5165 and a P = 0.0003. In all cases, the test statistics are significantly lower than the critical values, providing robust evidence that the first differences of the variables are stationary (Table 3). This ensures that the data are suitable for VAR modelling, as stationarity eliminates the risks associated with spurious relationships. The findings validate the use of first-differenced variables in the VAR model, supporting its capacity to accurately capture the dynamic relationships among the variables.

4.2. VAR Lag Order Selection

Results of the VAR lag order selection criteria for different samples and observations are summarised in the table below. Each criterion is analysed to determine the optimal lag order for the model. An asterisk (*) indicates the lag selected by each criterion.

The lag selection criteria reveal that for larger sample sizes (19, 18, and 17 observations), Lag 0 is consistently identified as the best choice across AIC, SC, HQ, and FPE metrics, indicating that the variables' current values adequately explain their behaviour without the need for lagged terms. Conversely, for the smaller sample size (16 observations), Lag 4 is recommended by all criteria, suggesting that incorporating a longer lag period is necessary to capture the dynamic interactions between variables. While Lag 0 ensures simplicity and minimises the risk of overfitting, Lag 4 offers a deeper insight into temporal dependencies (Table 4). The appropriate lag selection depends on the analysis's purpose: Lag 0 is suitable for simplicity and ease of interpretation, whereas Lag 4 is preferable for analysing dynamic relationships.

4.3. VAR Model Estimation Results

The vector autoregression (VAR) model applied to Sudan's economic indicators delves into the interrelationships between corruption perception, investment outflows, and unemployment. The analysis identifies key relationships that reveal the significant challenges facing Sudan economy (Table 5), particularly with the long-term effects of corruption on economic growth and labour market dynamics.

4.3.1. FDI outflow dynamics

The VAR results reveal a significant negative relationship between past and current FDI outflows, specifically with the lagged variable FDI outflow (−1) showing a coefficient of −1.702414, which is statistically significant with a t-statistic of −2.52168. This indicates that higher levels of FDI outflows in the previous period suppress current FDI inflows. This outcome reflects investor hesitation, which may be influenced by economic uncertainty, governance issues, and political instability, all of which are often associated with high corruption levels. The high explanatory power of the model ($R^2 = 0.771$) emphasises the critical role that past investment trends play in shaping the current investment climate in Sudan (Table 6).

These findings are consistent with the work of Mauro (1995) and Wei (2000), who assert that corruption increases the cost of doing business, deters foreign investment, and reduces the efficiency of public spending. Similarly, Apergis and Payne (2012) also found that corruption negatively impacts FDI, particularly in emerging markets where political and economic instability undermine investor confidence. In the Sudanese context, political instability and weak institutional frameworks, compounded by corruption, have historically discouraged foreign investments, creating a cyclical pattern where capital flight begets further investment hesitancy. The model's results highlight the urgency of adopting policies that stabilise the economic and political environment, restore investor confidence, and reverse this trend of capital outflows.

4.3.2. Unemployment and corruption perception

A significant finding from the VAR analysis is the delayed but strong positive relationship between corruption perception (CPI) and unemployment. The coefficient for CPI (−4) is 0.789339, with a t-statistic of 3.95818, indicating a highly significant relationship. This suggests that increases in corruption perception (lower CPI scores) over the previous periods are associated with higher unemployment in subsequent periods. The underlying reason for this relationship can be attributed to the erosion of institutional trust and investor confidence that accompanies high corruption, which stifles economic growth and reduces job creation.

This finding aligns with studies by Gupta et al. (2002) and Tanzi and Davoodi (2000), who argue that corruption can misallocate public resources, leading to lower levels of public investment in infrastructure and job creation. In Sudan, corruption has been a long-standing issue, and the results from the VAR model suggest that its negative effects on unemployment are not immediate but accumulate over time. High corruption discourages foreign direct investment, weakens public sector performance, and hinders the economy's capacity to generate employment. The high R^2 value (0.879) for the unemployment equation further underscores the importance of corruption perception in shaping labour market outcomes in Sudan.

The delayed impact of corruption on unemployment also reflects the long-term consequences of poor governance, reinforcing the argument put forward by North (1990), who emphasised the role of institutional quality in influencing economic performance. As corruption undermines public institutions, it results in economic inefficiency, which ultimately manifests in higher unemployment. Thus, addressing corruption through improved transparency and stronger governance frameworks is essential to fostering sustainable economic development and reducing unemployment in Sudan.

4.4. Granger Causality Test Results

The Granger causality test provides valuable insights into the direction of causality among the variables, highlighting the underlying dynamics at play in Sudan's economic system (Table 7).

The Granger causality test further enhances our understanding of the relationships between corruption, unemployment, and FDI outflows. The results indicate that changes in Sudan's CPI score are not Granger-caused by either FDI outflows or unemployment. This suggests that shifts in corruption perception are driven by broader, systemic factors such as political stability, governance reforms, or shifts in institutional frameworks, rather than by immediate economic conditions. This finding is consistent with the conclusions of Wei (2000), who found that corruption is largely driven by institutional factors and not by short-term economic fluctuations. Therefore, addressing the root causes of corruption requires a sustained focus on improving governance and institutional quality in Sudan.

The analysis shows no evidence that either CPI or unemployment Granger-cause changes in FDI outflows. Which suggests that FDI dynamics in Sudan are influenced by external factors outside the immediate economic environment, such as global economic trends, geopolitical events, and international investor sentiment. In the Sudanese context, factors like economic sanctions, instability in neighbouring regions, and fluctuations in oil prices may play a more significant role in influencing FDI. This finding aligns with Adebayo and Akinboade (2014), who argue that corruption and political instability, although significant, are often overshadowed by external global factors when it comes to FDI decisions in African economies.

The most notable Granger causality result pertains to unemployment, which is significantly Granger-caused by both CPI and FDI outflows. The P = 0.0019 for CPI and 0.0404 for FDI outflows indicate a strong and statistically significant delayed effect of corruption perception and investment patterns on unemployment. As corruption perception worsens (reflected by lower CPI scores), job creation stagnates, leading to higher unemployment. Similarly, the reduction in FDI inflows, driven by capital flight and lack of investor confidence, exacerbates the unemployment situation. These results underscore the importance of addressing both governance issues and investment climate factors to stabilise and improve the labour market in Sudan.

4.5. Variance Decomposition Analysis

Variance decomposition provides a detailed understanding of how changes in variables such as Sudan's CPI score, FDI outflows, and unemployment influence each other over time. This analysis offers insights into the key factors driving economic trends in Sudan.

4.5.1. Impact on CPI score

In the short term, variations in the CPI score are entirely explained by its own past values, accounting for 100% of its variability in the first period. Over time, however, the contribution of FDI outflows increases significantly. By the tenth period, investment outflows explain over 76.67% of the changes in corruption perception, while the influence of the CPI score itself declines to 23.31%. The role of unemployment remains negligible throughout the analysis period (Table 8).

In case of Sudan, this indicates that investment trends strongly influence perceptions of corruption over time. As capital flight and reduced investments intensify, they may reinforce public and investor perceptions of weak governance and institutional inefficiency, highlighting the need for targeted reforms.

4.5.2. Impact on FDI outflows

Initially, investment outflows are primarily influenced by their own lagged values, explaining 82.82% of the variability in the first period. However, as time progresses, the CPI score becomes a more dominant factor, contributing 62.83% by the fifth period and 77.79% by the sixth period. The influence of unemployment on investment outflows remains minimal, never exceeding 1% across the periods (Table 9).

This trend underscores the significant role of governance and corruption in shaping investment behaviour in Sudan. Addressing corruption and improving institutional transparency could be pivotal in stabilising investment flows and fostering economic growth.

4.5.3. Impact on unemployment

Unemployment is predominantly influenced by corruption perception throughout the analysis. In the first period, the CPI score explains 69.82% of the variability in unemployment, increasing to a peak of 93.62% by the fifth period. The contribution of FDI outflows is relatively modest, reaching 20.59% by the tenth period, while unemployment's own lagged values explain a negligible portion of its changes (Table 10).

For Sudan economy, this highlights the profound and sustained impact of corruption perception on the labour market. High levels of corruption can deter investments, disrupt economic activities, and undermine job creation, making governance reforms essential to tackling unemployment effectively.

The variance decomposition results emphasise the interconnected nature of governance, investment, and labour market dynamics in Sudan. Corruption perception plays a critical role in influencing both unemployment and investment outflows over time, while the impact of unemployment on the other variables remains minimal. These findings underline the importance of institutional reforms aimed at reducing corruption and stabilising investment dynamics to promote sustainable economic development in Sudan.

4.6. Impulse Response Function Analysis

The impulse response function (IRF) analysis examines how changes in one variable — CPI score, FDI Outflow, or Unemployment — affect the others over time. This provides insights into the dynamic interactions among these variables in Sudan's economic context.

4.6.1. Response of CPI

This variable is heavily influenced by investment outflows, reflecting the interplay between financial trends and governance perceptions.

The CPI score shows a highly variable response to its own shocks. Initially, the reaction is positive, with a value of 4.881 in the first period (Table 11). However, over time, the response becomes negative in some periods, such as −3.666 in the second and −6.032 in the sixth period, before turning highly positive again in the tenth period (14.963). This pattern reflects significant instability in the governance environment.

The influence of FDI outflows on the CPI score grows over time, with notable positive effects in periods such as the fourth (1.870) and sixth (2.289). However, negative impacts emerge in the later periods, most prominently in period eight (−6.862). On the other hand, shocks to unemployment have little to no direct impact on the CPI score, with responses remaining negligible throughout the observed periods.

For Sudan, this volatility in CPI score responses indicates that governance perceptions are sensitive to financial trends, particularly FDI outflows. The minimal influence of unemployment highlights that broader economic conditions may not directly impact the CPI score in the short term.

4.6.2. Response of FDIO

FDI outflows react dynamically to shocks in the CPI score. While initial effects are relatively small, significant reactions occur in later periods. For example, positive responses peak in the fourth (11.721) and sixth (21.198) periods, but large negative reactions follow, such as −124.691 in the tenth period. These fluctuations point to the critical role of governance in driving investment behaviour.

FDI outflows also respond strongly to their own shocks, starting with a positive impact (2.632) in the first period but shifting to negative values (−4.890) in the second. These fluctuations continue throughout the time horizon, reflecting a highly unstable investment environment. The influence of unemployment on FDI outflows remains minimal across all periods, with negligible effects observed.

The FDI outflows are highly sensitive to corruption perception shocks, showcasing the role of governance in determining investment stability. The sensitivity of investment outflows to changes in the FDI score in Sudan underscores the importance of improving governance to stabilise financial flows. The observed volatility suggests that economic uncertainty, likely driven by governance challenges, heavily influences investor decisions.

4.6.3. Response of UNEM

Unemployment consistently exhibits a positive response to CPI score shocks in the short term (Table 13). For example, the initial

impact is 1.130 in the first period, rising to 3.372 by the fifth period. However, this response stabilises in the later periods and turns slightly negative in the tenth period (−1.552).

The effects of FDI outflows on unemployment are relatively modest, with positive and negative impacts alternating over time. The strongest influence is observed in period 10 (1.668). Shocks to unemployment itself have only a minor and diminishing impact, with the response turning negative in later periods.

This means that labour market outcomes are primarily driven by corruption perception, while investment outflows play a secondary but notable role.

The persistent positive response of unemployment to corruption perception shocks in Sudan highlights the detrimental impact of governance issues on the labour market. While investment outflows also play a role, their effect is less pronounced compared to the influence of corruption perception.

The impulse response analysis reveals strong interdependencies among governance, financial stability, and labour market conditions in Sudan. The CPI score emerges as a critical driver, significantly influencing both FDI outflows and unemployment over time. Stabilising governance structures and improving institutional transparency are essential for reducing economic volatility and fostering sustainable growth.

4.7. VAR Residual Normality Test Results

The VAR residual normality test evaluates whether the residuals from the model conform to a multivariate normal distribution. This is determined by analysing three components: skewness, kurtosis, and the combined Jarque-Bera test. The results of these tests indicate that the residuals generally meet the assumptions required for valid model inference.

The skewness test assesses the symmetry of the residuals. For all three components, the P-values are >0.05 (0.1993, 0.1107, and 0.2572 for Components 1, 2, and 3, respectively), which suggests that the residuals do not deviate significantly from symmetry.

The joint skewness test across all components also supports this finding, with a P = 0.1401, indicating no significant skewness in the residuals.

The kurtosis test examines whether the residuals exhibit excess kurtosis. The P-values for Components 1, 2, and 3 (0.8951, 0.2450, and 0.6438, respectively) are all above the 0.05 threshold, suggesting that the residuals have acceptable levels of kurtosis. The joint kurtosis test produces a P = 0.6633, confirming that the residuals do not display significant excess kurtosis when considered collectively.

Finally, the Jarque-Bera test evaluates the combined effects of skewness and kurtosis to assess overall normality. The P-values for the individual components (0.4349, 0.1425, and 0.4730 for Components 1, 2, and 3, respectively) indicate that none of the residuals deviate significantly from normality. The joint Jarque-Bera test yields a P = 0.3154, further affirming that the residuals of the VAR model are multivariate normal (Table 14).

In conclusion, the results of the normality tests show that the residuals conform to the assumptions of multivariate normality. The absence of significant skewness or kurtosis ensures the reliability and validity of the VAR model, making it suitable for further analysis and forecasting.

4.7.1. Adjusted VAR residual portmanteau test for autocorrelations

The adjusted VAR residual portmanteau test evaluates whether the residuals of the VAR model exhibit autocorrelation across specified lags. The results show that at all tested lags (1-4), the P-values for the Q-statistic and adjusted Q-statistic exceed the standard significance threshold of 0.05. For instance, at lag 1, the P-values are 0.2572 and 0.1993, while at lag 4, they are 0.4730 and 0.3154. These values indicate that the residuals are independent across time, suggesting no significant autocorrelation (Table 15). This outcome implies that the VAR model is well-specified and effectively captures the dynamics of the variables.

The absence of residual autocorrelation has positive implications for the reliability and validity of the VAR model. It confirms that the chosen lag structure is appropriate and that the model successfully captures the interdependencies among the variables without leaving unexplained patterns in the residuals. Additionally, this enhances the reliability of the model's forecasts and analytical outputs, such as impulse response functions and variance decompositions. To further validate these findings, complementary diagnostics, such as the LM serial correlation test, can be conducted.

5. CONCLUSION AND POLICY IMPLICATIONS

This study has explored the dynamic interactions between corruption perception, unemployment, and foreign direct investment (FDI) in Sudan using a vector autoregression (VAR) model. The results highlight the critical role of corruption in shaping both investment behaviour and labour market outcomes, emphasising its long-term effects on Sudan's economic development. The findings indicate that corruption not only deters foreign investment but also contributes significantly to higher unemployment levels over time. These relationships align with the broader literature, such as the works of Wei (2000) and Mauro (1995), which highlight how corruption raises business costs and undermines economic stability. Specifically, the model shows that increases in perceived corruption (lower CPI scores) lead to a delayed rise in unemployment, suggesting that corruption's negative impact on investor confidence and economic growth accumulates over time.

Furthermore, the study reveals a complex relationship between FDI outflows and corruption, where past levels of capital flight contribute to a reduction in future FDI inflows. This cyclical pattern underscores the broader issue of political instability and

weak institutional frameworks in Sudan, which have historically been exacerbated by corruption. The results mirror those found by Apergis and Payne (2012), who emphasise the destabilising effects of corruption on investment in emerging markets. For Sudan, this implies that a persistent lack of investor confidence and economic uncertainty, driven by corruption, further deepens the challenges of attracting and retaining foreign investment. The VAR model's variance decomposition and impulse response functions further reinforce the importance of governance in influencing both investment flows and labour market dynamics.

In light of these findings, it is evident that addressing corruption and improving institutional quality are essential for Sudan's economic recovery and long-term growth. Policymakers should focus on enacting reforms that promote transparency, accountability, and the strengthening of legal and regulatory frameworks. Anti-corruption measures should be at the forefront of these reforms to reduce the costs associated with doing business and enhance the country's attractiveness as an investment destination. Additionally, improving governance will likely have a positive impact on job creation by restoring investor confidence and encouraging foreign direct investment. By fostering a stable, transparent, and accountable governance environment, Sudan can reduce its unemployment rate and create a more favourable environment for economic development, aligning with the insights of North (1990) on the importance of strong institutions for fostering economic growth. Therefore, targeted institutional reforms and the reduction of corruption are key steps in promoting sustainable economic development in Sudan.

For clarity and consistency throughout the analysis, a list of key acronyms used in the study has been provided. These include standard econometric and economic terms such as ADF, CPI, FDIO, and VAR, among others. This list serves to enhance reader comprehension and ensure accurate interpretation of the technical terminology employed in the model and results discussion (Table 15).

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