ISSN: 2658-8455
Volume 6, Issue 4 (2025), pp. 86-106.

IJAFAME
International Journal of Accounting, Finance, Auditing, Management & Economics

The impact of AI technologies on economic growth, productivity, and governance: VAR analysis in Moroccan territory

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Disclosure Statement :	Authors are not aware of any findings that might be perceived as affecting the objectivity of this study, and they are responsible for any plagiarism in this paper.
Conflict of Interest :	The authors report no conflicts of interest.
Cite this article :	MARSOU, Y. (2025). The impact of AI technologies on economic growth, productivity, and governance: VAR analysis in Moroccan territory. *International Journal of Accounting, Finance, Auditing, Management and Economics*, *6*(4), 86-106. https://doi.org/10.5281/zenodo.15126387
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Received: January 31, 2025 *Accepted: March 29, 2025*

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Abstract

This study aims to discuss the impact of AI technologies on economic growth and governance to promote new strategies based on AI in Moroccan territory. AI industry performed the development engine infrastructure and automated tasks into the needs of the territory. In this research, we explore the relationship between AI variables, Economic growth, productivity variables, and governance variables. The study's originality displays that Moroccan public policies adhere to AI compliance strategies to promote productivity and boost government performance into territory insights. Furthermore, we conduct our analysis in two steps; the first one is to load factors in PCA and the second one is to build VAR and SVAR model to conduct algorithms and promote new strategies for AI integration in local specificity of the Moroccan model in R language using Rstudio software. This method is useful to predict algorithms based on information on the past and predict their future modeling impact to facilitate planning for new policies and boost their performance strongly for decision-making process in data frame 2011-2022. As well as this period involves short-term dynamics under the limit of 1 to 2 lags. Either, the results show that AI has a significant role on the governance indicators, economic growth and productivity. Moreover, policymakers should consider AI impact on employment strategies and boost governance quality towards local actors in Moroccan territory.

Keywords: AI technologies- Moroccan territory - Economic growth and productivity- Governance
JEL classification: H1, J20, O3, O43, O47
Paper type : Empirical research

Résumé

Cette recherche a pour objectif d'étudier l'impact des technologies d'IA sur la croissance économique et la gouvernance afin de promouvoir de nouvelles stratégies basées sur l'IA au niveau du territoire marocain. L'industrie de l'IA a construit l'infrastructure du moteur de développement et répondre au besoin du territoire à travers l'automatisation des tâches. Dans cette recherche, nous explorons la relation causale entre les variables de l'IA, les variables de croissance économique, de productivité et les variables de gouvernance. D'où l'originalité de l'étude, montre que les politiques publiques marocaines adhèrent aux stratégies de conformité de l'IA pour promouvoir la productivité et stimuler la performance gouvernementale dans les données perspectives du territoire. En outre, nous effectuons notre analyse selon deux étapes ; premièrement établir une analyse factorielle PCA, et deuxièmement, construire le modèle VAR et SVAR, dans le but de conduire des algorithmes et de nouvelles stratégies pour l'intégration de l'IA dans la spécificité locale du modèle marocain. Cette méthode est utile pour prédire les algorithmes basés sur des informations du passé et prévoir leur impact futur afin de faciliter la planification de nouvelles politiques et d'augmenter leur performance dans le processus décisionnel dans la base de données 2011-2022. De plus, cette période implique une dynamique à court terme sous la limite de 1 à 2 retards, soit les résultats de l'étude montrent que l'IA joue un rôle significatif sur les indicateurs de gouvernance, la croissance économique et la productivité. Sachant que les décideurs politiques devraient tenir compte de l'impact de l'IA sur les stratégies d'emploi et renforcer la qualité de la gouvernance auprès des acteurs locaux sur le territoire marocain.

Mots clés : technologies d'IA- territoire marocain – croissance économique et productivité- gouvernance
Classification JEL: H1, J20, O3, O43, O47
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ISSN: 2658-8455
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1. Introduction

Artificial intelligence facilitates optimal and productive choices when exploiting territorial resources. Hence, AI has a constructive role in integrating into the economic intelligence ecosystem. These allow local actors to deliver multiple versions generated by the black boxes to the generic development simulation. Based on the algorithms of variables through the analysis of productivity and economic growth.

This research displays the role of AI in economic growth and governance besides public policies. We measure each component by representative variables to indicate the impact on the economic side and promote AI investment projects.

However, AI is key to accelerating innovation at the macroeconomic level in various industries and to widespread adoption to revive sluggish productivity growth and to raise well-being. However, many challenges restricted the process of human intervention. AI is an umbrella term that refers to a computer system that can sense, reason, and act like humans (Brynjol, 2023). It leads people to stock actions as material data towards expected problems. By the use of LLM large language model or DL deep learning, AI can employ probabilistic models to predict outcomes and give recommendations.

In this paper research, we explore how AI compliance can promote employment and labor force through governance in Moroccan territory throughout 2011-2022. So the research question is: To what extent does AI affect productivity, economic growth, and governance of the Moroccan economy? To respond to the problematic research based on data panels and perform our results on VAR analysis. To predict the algorithm for SVAR analysis threw the caption of three variables, which refer to strategic governance policy thought Kaufman indicators, economic growth and productivity strategies and AI uses.

Therefore, the research gap is to address the key variables defined by PCA analysis and investigate the short-run impact of artificial intelligence as an ICT solution in the decision-making process. The broad objective of this study is to explore the impact on the decision-making process by the use of AI to promote productivity and economic growth as our model research design.

AI is considered to have the potential to instigate a fourth industrial revolution and change people's patterns of production and physical capital and labor. AI integration by the ability to automate tasks, optimize processes, and make predictions can enhance overall efficiency and productivity in various industries (Aghion et al., 2018; Furman and Seamans, 2019).

AI targets technological change in investment opportunities and economic growth (Romer, 1990; Aghion and Howitt, 1992; Kogan et al., 2017). The interest in investing in AI technologies is to promote productivity and high-quality governance, where many studies discuss the impact of AI use on the Labor force (Acemoglu et al., 2022). In our research, we consider global variables to measure the impact of AI technologies on the governance system in Moroccan territory and promote new strategies by analyzing the algorithms of series in VAR analysis. This study took place to reinforce the adoption of AI in the future model of development, as well as the identification of AI in an institutional environment, which is very vulnerable due to insufficient materials and expenditure.

Governance quality sets many items to reinforce economic development within the country to foreign investment for transparency, political stability, and regulatory frameworks (Chhabra et al. 2023). The role of governance in performance indices shows interest in AI technologies in productivity and economic growth.

Furthermore, we demonstrate through the study hypothesis that the time path of representative compliance of variables determines factors subject to sum up the representability of variables showing the impact on government quality, productivity, economic growth, and AI

technology's impact. To the author's knowledge, there is a dearth of studies investigating the interplay relationships between the variables in the time path graph.
Therefore, the research gap addresses the key variables defined by PCA analysis and investigates the short-run impact of artificial intelligence as an ICT solution in the decision-making process. The broad objective of this study is to explore the impact on the decision-making process of the use of AI to promote productivity and economic growth as our model research design.

2. Literature review

Artificial intelligence technologies and economic aggregates

AI technologies have posed challenges to understanding their impact on economic aggregates (Seamans and Raj, 2018). Bessen (2017) finds that new technologies have a positive impact on employment in less saturated manufacturing industries. Recent academic studies show that AI compliance boosts economic growth and responds to the needs of humans through computer algorithms; it performs many of the functions that a human can (Frey and Osborne 2017, Furman 2016). AI industry performed until sufficient scale foreword to blossom in aggregate economic data, through strategic policies and infrastructures dedicated to investors and policy makers in the development engine. (Brynjolfsson, & al, 2019). AI systems solve complex problems into a bunch of simple prediction tasks. It uses instances of machine learning ML as components of the larger system, and then the components are organized within a structure by domain specificity within prediction tasks (Matt T, 2018). Thus far, substitution between humans and AI is considered costs and automated tasks, whereby the decision-making process is matched with productivity level (Agrawal, Gans, and Goldfarb, 2018).
Economists affirm that the use of automation tasks had income gains, but political and social contributors ask about redistribution and structure benefits (Stevenson, B, 2019). The IGM Economic Experts Panel 2014 stated that advanced automation did not negatively affect employment in the United States and can complete automated tasks through AI to increase productivity and raise labor demand by deepening automation (Acemoglu and Pascual Restrepo, 2019). The assumptions toward AI and economic aggregates suppose that:

- AI has a positive effect on employment and productivity;
- AI, as deepening automated tasks, increases productivity, incomes, and labor force;
- AI can promote investment in the territory through its benefits to society and complete human needs.

AI and governance

Governance has two purposes: institutional governance and quality governance. We based our analysis on the Kaufman WGI world governance indicators as popular indices in Moroccan territory. In this research, we seek the impact between AI and Governance in territory. In this case, it is to promote the governance performance of actors and respond to the needs. Kaufman indicators (Kaufmann, D., Kraay, A., & Mastruzzi, M., 2004) are useful to seek for good governance and sustainable development, where are adopted by policymaker's researcher despites the specificity of local economy in international organization, it combine six dimensions:

- Voice and accountability;
- Political stability and absence of violence/terrorism;
- Government effectiveness;
- Regulatory quality;
- Rule of law;
- Control of corruption;

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Volume 6, Issue 4 (2025), pp. 86-106.

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AI compliance has a direct impact on digital governance towards data collected and human needs. E-governance employs digital space, and AI tools can discover inequalities. In regard to; the state regulation of internet content, the creation of statist closed digital networks, and governance of intellectual property, where algorithmic nudging and digital surveillance mediate governance digital spaces (Zwitter.A, Gstrein.J.O, 2023).

Moroccan territory

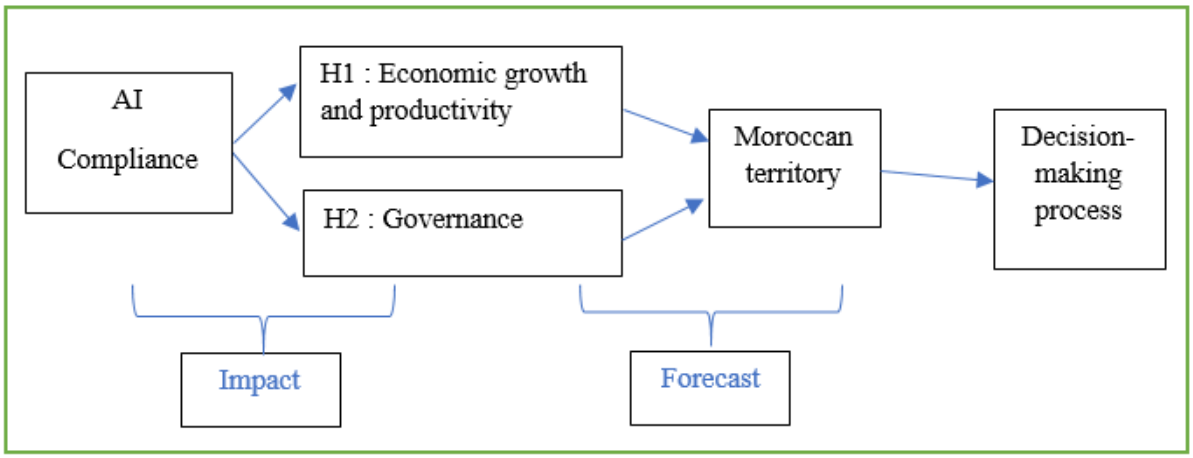
Moroccan territory as space exposes the consistency of public policies and actors of government. Governance is a key to resource investment. When the local needs are transmitted to informational data, it leads digital governement actor to manage their decision-making process and upgrade the performance of territory. In Morocco, governance has a major role in institutions to perform regulation, policies, and security state of population, as it is indicated in world governance indicators. However, governance reports the stability in institutional relation in territory though the programs and projects in case to make the space more attractive for foreign investment. In this study, we will forecast the impact of AI on Governance indicators and economic growth and productivity. AI strategies were denounced by CESE (2024) as a national priority in digitalization and development. The General Assembly of Committee on knowledge and information society Session of 27 June 2024 agreed that:

- AI may increase global GDP up to 14% by 2030;
- AI improves governance in society and responds to the needs in educational, health, and administration fields;
- AI challenges in employment patterns, privacy risks in collected data, and biased output;
- Moroccan territory can adopt AI despite the regulatory environment relating to cybersecurity protection consumer;
- There is a lack of AI specialists to manage programs and promote solutions for the economic priorities of Morocco.

Research gap

Despite empirical literature on the nexus of economic growth and productivity AI technologies, to the best of our knowledge, no studies have examined how Moroccan public policies adhere to AI compliance strategies to promote productivity and boost government performance action survey on the territory insights (Figure 1).

Figure 1: Model research



Source: Author

3. Methodology

3.1 Empirical strategy

The empirical strategy displays econometric approaches to longitudinal series. The preliminary empirical strategy leads to summing up variables in principal components analysis PCA, declaring time series factors, ACF test, unit roots, building VAR model, normality/ cointegration / and homoscedasticity test, stability test (ols-cusum), Granger causality, variance decomposition, and forecasting algorithms to predict new strategies.
However, we focused on studying the econometrics model, Vector autoregressive analysis, and estimation techniques in the Language R console by R studio software.

3.2 Theoritical and empirical model

The reasoning was conducted to analyze AI compliance to perform productivity, economic growth, and governance. Whereas the aggregate growth function illustrates the Cobb-Douglas (Cobb and Douglass 1928) production function and Solow-Swan (Sollow 1956; Swan 1956) for Moroccan territory specificity, as below:

$$Y_{i,t} = f(K_{i,t}, L_{i,t}) \quad (1)$$

$$Y_{i,t} = Ak_{i,t}^{\ ß}\ L_{i,t}^{\ 1-ß} \quad (2)$$

" Y, K, L, A": represent GDP per capital, capital, labor force, and technical progress
The Solow-Swan function (2) leads to the conclusion that technological progress is a key driver of output. AI, as a transformative technology, can contribute to productivity gains and innovation, leading to increased output. This theory posits that AI's ability to automate tasks, optimize processes, and make predictions can enhance overall efficiency and productivity in various industries (Aghion et al., 2018; Furman and Seamans, 2019). AI can foster economic growth through IT technical solutions (Brynjolfsson and McAfee, 2014), either to perform efficiency on governance among transformative processes.
The vector autoregressive model analyzes short-run public policies based on algorithm behavior generated in the data panel. The General VAR model has many parameters, too difficult to interpret due to complex interactions and feedback between the variables. As a result, the dynamic properties of a VAR model are summarized using various types of structural analysis SVAR in three steps: Granger causality test, impulse response functions, and forecast error variance decompositions.
In our study, we suppose that all variables are endogenous, and restrictions are imposed with statistical techniques instead of prior beliefs based on uncertain theoretical considerations (Lutkepohl, H, 2004). Yet the time series estimated as below:

aiinvest = aiinvest.l1 + employlaborfdi.l1 + GDP.l1 + Governancequality.l1 + Governancestab.l1 + const (3)

employlaborfdi = aiinvest.l1 + employlaborfdi.l1 + GDP.l1 + Governancequality.l1 + Governancestab.l1 + const (4)

GDP = aiinvest.l1 + employlaborfdi.l1 + GDP.l1 + Governancequality.l1 + Governancestab.l1 + const (5)

Governancequality = aiinvest.l1 + employlaborfdi.l1 + GDP.l1 + Governancequality.l1 + Governancestab.l1 + const (6)

Governancestab = aiinvest.l1 + employlaborfdi.l1 + GDP.l1 + Governancequality.l1 + Governancestab.l1 + const (7)

All variables are computed through PCA to resume component-representing factors in each axis. The data collected forms three insights:

- Economic growth and productivity;
- AI compliance;
- Governance.

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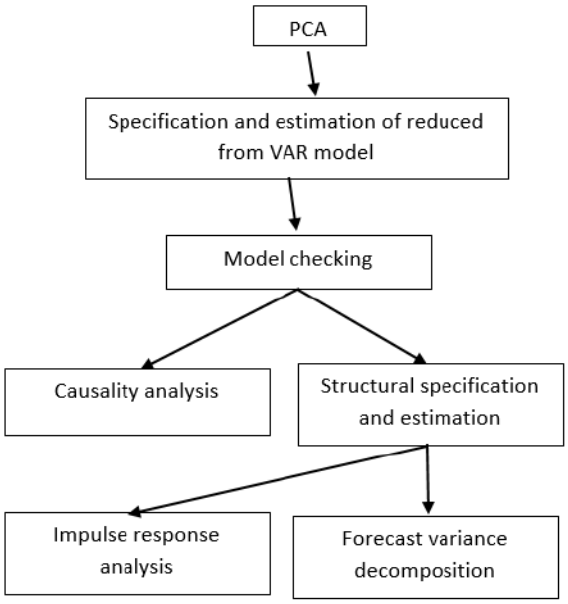
The purpose of the analysis is to drive public policies and promote new strategies for forecasting functions in the VAR model in Moroccan territory.

Figure 2: Summary of the econometric approaches



Source: Lutkepohl H 2006 Vector autoregressive models. In ¨ Palgrave Handbook of Econometrics, Vol. 1, Econometric Theory (eds Mills TC and Patterson K), pp. 477–510. Palgrave Macmillan, Basingstoke.

Table 1: Variables description

Panels	Variables	Abreviation	Database
Panel 1: Economic growth and productivity computed in PCA by author -GDP -employlaborfdi	Employment to population ratio+15% total	employment	WDI
	Labor force participation +15 % total ratio	Labor	WDI
	GDP per capital growth % annual	GDP	WDI
	Foreign Direct investment	FDI	WDI
Panel 2: AI Trends computed in PCA by author -aiinvest	Research and development expenditure % of GDP	RD in GDP	WDI
	Individuals using internet % of population	Internet	WDI
	investment in ICT with private participation	ICT	WDI
	AI software dev to public AI project	AI software	OCDE
	investment in AI	Aiinvest	OCDE
Panel 3: Governance computed in PCA by author -Governance quality -Governancestab	governement effectiveness: estimate	gov effectiveness	WDI/ WGI
	political stability and absence of violence estimate	political stab	WDI/ WGI
	Voice and accountability estimate	voice	WDI/ WGI
	control of corruption: estimate	control corrup	WDI/ WGI
	regulatory quality	REQ	WDI/ WGI
	Rule of law	Rlaw	WDI/ WGI

Note: WDI represents the World Bank's Word Development Indicators. WGI World Governance Indicators.

4- Empirical results and discussion

4.1 Preliminary analysis

Table 2 shows the principal components results. The eigenanalysis shows that the first two principal components have eigenvalues greater than 1, otherwise, the pc3 has only 0.791. In addition to PC1, PC2 accounts 55.2% and 83.1% of the variance, and both account for 83.6% of explained variance.
The loading eigenvectors shows the most correlated variable by the component; the first component has high loadings on employment (0,598), labor (0,657), and negative correlation on FDI (-0.432), for the second component has negative high loadings on GDP (-0.872).

Table 2: PCA results for panel 1

correlation matrix

	Employment	Labor	GDP	FDI
employment	1.000000	0.8675088	0.01665017	-0.3483496
Labor	0.86750879	1.0000000	0.35608682	-0.5099324
GDP	0.01665017	0.3560868	1.000000	0.1388716
FDI	-0.34834957	-0.5099324	0.13887158	1.0000000

Eigenvalue

	comp 1	comp 2	comp 3	comp 4
eigenvalue	1.4860181	1.0660069	0.7912945	0.1709746
proportion of variance	0.5520625	0.2840927	0.1565367	0.007308085
cumulative proportion	0.5520625	0.8361552	0.992619	1.00000000

loadings eigenvectors

	comp 1	comp 2	comp 3	comp 4
employment	0.598		0.558	0.571
Labor	0.657	-0.158		-0.734
GDP	0.152	-0.872	-0.363	0.291
FDI	-0.432	-0.459	0.743	-0.222

Loadings factor (varimax)

	factor 1
employment	0.869
Labor	0.998
GDP	0.351
FDI	-0.509

Test of the hypothesis that 1 factor is sufficient.
The chi-square statistic is 10.25 on 2 degrees of freedom.
The p-value is 0.00596

Source: author computation

Table 3 shows the principal components results. The eigenanalysis shows that the first principal components have eigenvalues greater than 1, otherwise, the pc2 has only 0.963. In addition to pc1, 65% of the variance account for 65.6% of the explained variance.
The loading eigenvectors show the most correlated variable by the component, the first component has high loadings on AI investment (0,684), Internet (0,681), hence PC1 is strongly

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associated with these variables, for the second component has high loadings on AI software with (0.965).

Table 3: PCA result for panel 2

Correlation matrix			
	Internet	AI Investment	AI software
Internet	1.000000	0.8971882	-0.1775850
AI Investment	0.8971882	1.0000000	-0.1956464
AI software	-0.1775850	-0.1956464	1.0000000
eigenanalysis of the correlation Matrix			
	comp 1	comp 2	comp 3
eigenvalue	1.4032351	0.9634882	0.32034646
proportion of variance	0.6563562	0.3094365	0.03420728
cumulative proportion	0.6563562	0.9657927	1.000000

loadings eigenvectors			
	PC 1	PC 2	PC 3
Internet	0.681	0.196	0.705
AI Investment	0.684	0.175	-0.709
AI software	-0.263	0.965	
loadings varimax			
	Factor 1		
Internet	0.902		
AI Investment	0.994		
AI software	-0.197		

Test of the hypothesis that 1 factor is sufficient.
The chi-square statistic is 10.25 on 2 degrees of freedom.
The p-value is 0.00596

Source: author computation

Table 4 shows the principal components results. The eigenanalysis shows that the first two principal components have eigenvalues greater than 1, otherwise, the pc3 has only 0.807. In addition to pc1,pc2 accounts 47% and 33.2% of the variance, respectively, and both account for 80.6% of explained variance.

The loadings eigenvectors shows the most correlated variable by the component, the first component has high loadings on Rule of law (0,59), governement effectiveness (0,556), and control corruption (0.532), hence PC1 is strongly associated with these variables, for the second component has negative high loadings on (political stability with (-0.604), voice accountability with (-0.484) and regular quality (-0.573).

Table 4: PCA results for panel 3

Correlation matrix	governance effectiveness	political stability	Voice accountability	control corruption	Regulatory quality	Rule of law
government effectiveness	1.00000000	0.22871	0.15990089	0.7905103	0.006368671	0.9103943
political stability	0.22871782	1.00000	0.53552090	-0.1236886	0.559822848	0.2240329
voice accountability	0.15990089	0.53552	1.00000000	0.0400936	0.315815768	0.2749417
control corruption	0.79005131	-0.12368	0.04009365	1.0000000	-0.298047085	0.9212602
regulatory quality	0.00636867	0.55982	0.31581577	-0.298047	1.00000000	-0.058918
Rule of law	0.910394379	0.22403	0.27494173	0.9212602	-0.058918466	1.0000000

Eigenanalysis of the correlation Matrix						
	comp 1	comp 2	comp 3	comp 4	comp 5	comp 6
eigenvalue	1.684831	1.41349	0.8079629	0.6075633	0.3677352	0.0788208
propotion	0.473109	0.33299	0.1088007	0.0615222	0.0225382	0.0010354
cumulative	0.473109	0.80610	0.9149041	0.9764263	0.9989645	1

Loadings eigenvectors

variable	PC1	PC2	PC3	PC4	PC5	PC6
governement effectiveness	0.556		0.247		0.762	0.205
political stability	0.153	-0.604		0.725	-0.242	0.151
Voice accountability	0.188	-0.484	-0.770	-0.334	-0.142	
control corruption	0.532	0.267		-0.185	-0.528	0.576
Regulatory quality		-0.573	0.583	-0.566		
Rule of law	0.590				-0.228	-0.774

Loadings Factors

	Factor 1	Factor 2
governement effectiveness	0.882	0.235
political stability		0.892
Voice accountability	0.190	0.582
control corruption	0.967	-0.244
Regulatory quality	-0.150	0.631
Rule of law	0.988	0.141

Test of the hypothesis that 2 factors are sufficient.
The chi-square statistic is 4.59 on 4 degrees of freedom.
The p-value is 0.332

Source: author computation

We denote factors in PCA results recapitulated in five variables for each variable. We conclude that economic growth and productivity are represented in two factors "employlaborfdi" and "GDP". The second factor represents “aiinvest”, and the last one represents governance policy through two components “Governancequality”, and “Governancestab”. We choose PCA analysis to measure analytic contingency on public policies on the specificity of Moroccan territory. It facilitates the construction of the VAR model and predicts algorithm development. Thereby, the screen plots provide additional support for PCA findings (Appendix 1).

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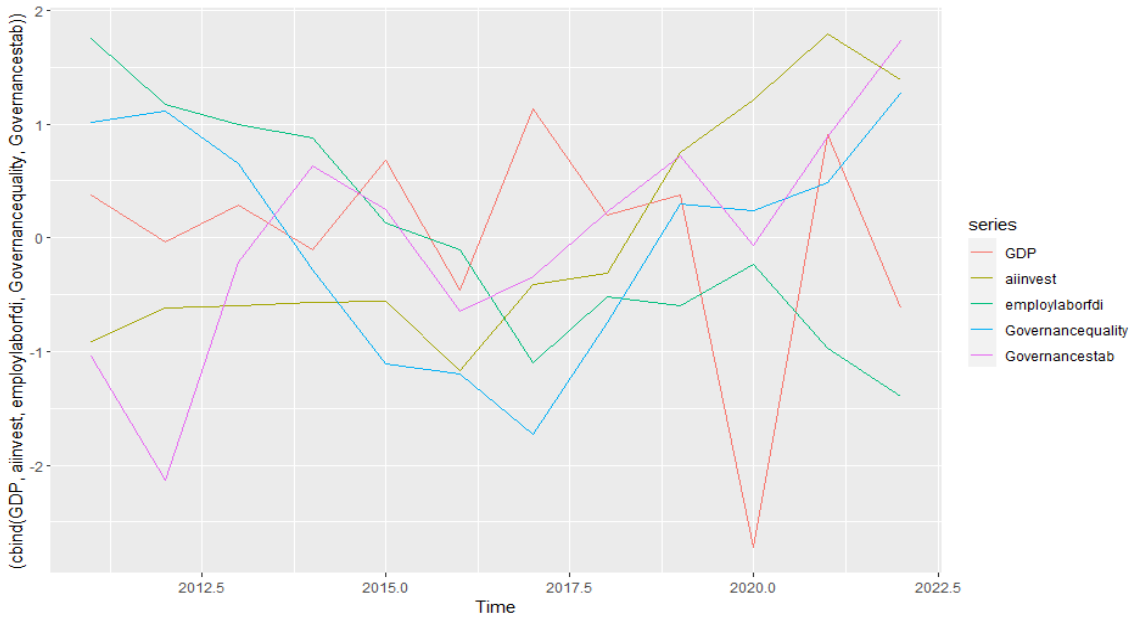
4.2 VAR model

We construct VAR model based R language functions and project outputs results. We follow the steps indicated in VAR analysis to predict algorithms in Structural VAR. It leads to predict Moroccan attitude toward each variable as economic ecosystem and public policies as well.

Figure 3: Time series path graph variables (GDP,aiinvest,employlaborfdi, Governancequality,Governancestab)



Source: Rstudio software output

4.2.1 Declare time series

The analysis was conducted in R language; to the best knowledge of the author, no study was conducted before to measure the impact on governance, AI compliance, and economic growth and productivity. Therefore, we will focus on interpreting and discussing the impact of AI compliance on productivity and governance in Moroccan territory.
The coding function table 5 shows the time series varying from 2011-2022. This panel led us to generate an algorithm based on Moroccan specificity and mobilize action to develop projects in AI, economic growth, and governance.

Table 5: The time series variables from 2011- 2022

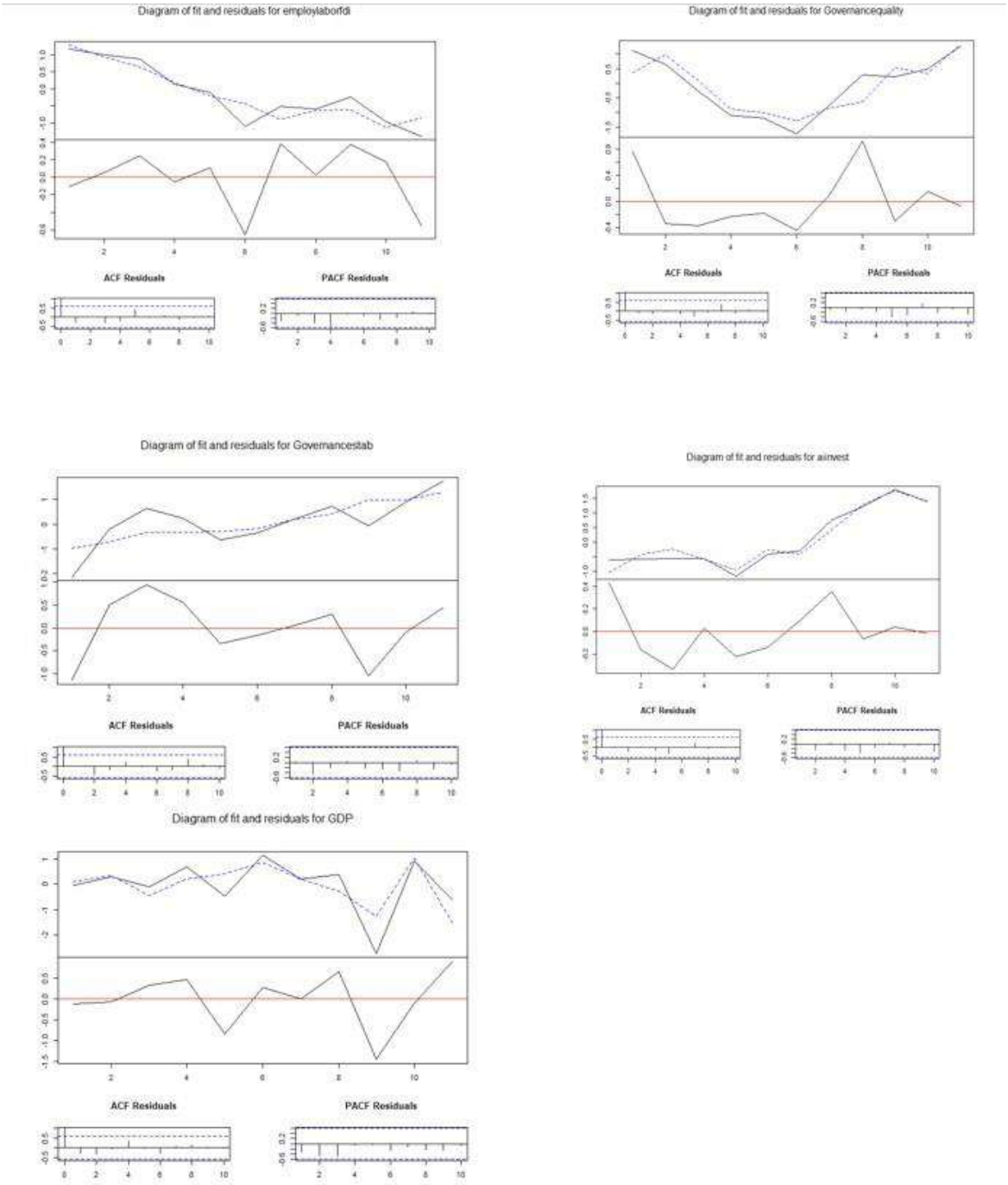
R console	Results
> aiinvest <- ts(MAROC$aiinvest, start = c(2011,1), frequency = 1)	aiinvest = aiinvest.l1 + employlaborfdi.l1 + GDP.l1 + Governancequality.l1 + Governancestab.l1 + const
> employlaborfdi <- ts(MAROC$employlaborfdi, start = c(2011,1), frequency = 1)	employlaborfdi = aiinvest.l1 + employlaborfdi.l1 + GDP.l1 + Governancequality.l1 + Governancestab.l1 + const
> GDP <- ts(MAROC$GDP, start = c(2011,1), frequency = 1)	GDP = aiinvest.l1 + employlaborfdi.l1 + GDP.l1 + Governancequality.l1 + Governancestab.l1 + const
> Governancestab <- ts(MAROC$Governancestab, start = c(2011,1), frequency = 1)	Governancestab = aiinvest.l1 + employlaborfdi.l1 + GDP.l1 + Governancequality.l1 + Governancestab.l1 + const
>Governancequality <- ts(MAROC$Governancequality, start = c(2011,1), frequency = 1	Governancequality = aiinvest.l1 + employlaborfdi.l1 + GDP.l1 + Governancequality.l1 + Governancestab.l1 + const

Source: author computation

4.2.2 ACF and lag selection

Figure 4 presents the model residuals that are white noise, with their ACF and PACF falling within their 95% confidence interval with one lag order in the first year.

Figure 4: Diagram of fit residuals



Source: Rstudio software output

The lag length selection (Table 6) indicates the optimum is 1 following the result of the three information criteria. The optimum of the Moroccan model is 1 lag order selected by the AIC Akaike information Criterion. SIC is the Schwarz information Creterion, and Hannan-Quinn information Creterion. Those results mean that we can continue our VAR analysis building algorithms between variables. It shows that we confirm that VAR Maroc is first indifferent and displays a unit root in the heteroscedasticity test.

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Table 6: Lag selection 1st order

Lag	1 order
AIC	-8.5709514
HQ	-9.2549984
SIC	-7.4857824
FPE	0.00036822

Source: Author computation

4.2.3 Augmented dickey fuller (Adf) test unit root/ cointégration test:

Table 7: Augmented dickey Fuller test

Data	GDP	employlaborfdi	aiinvest	Governancequality	Governancestab
Dickey-fuller	-3.8176	-2.6085	-3.0047	-1.2698	-1.8536
Lag order	2	2	2	2	2
p-value	0.03446	0.3406	0.1896	0.8505	0.6281
Results	p-value <0.05 nonstationary data	p-value >0.05 stationary data	p-value >0.05 stationary data	p-value >0.05 stationary data	p-value >0.05 stationary data

Source: Author computation

4.2.4 Building VAR (MAROC)

We conduct that analysis in R functions, after the heteroscedasticity, lag selection, all variables integrate in 1 order and residuals has normal distribution, thereby we continue to build VAR (Maroc) through the functions.

Table 8 shows VAR Estimation Results, We have five endogenous variables and a constant as deterministic one. The log likelihood (-0.901), and all variables has units roots (aiinvest (1.133), employlaborfdi (0.7949), GDP (0.7949), Governancequality (0.7141), Governancestab (0.1069)). According to Lutkepohl (2004), the estimated residuals aligned with white noise assumption in VAR model. It considered a set of test related to residual autocorrelation normality test and stability plots of residuals.

Table 8 5: VAR model (MAROC) estimation Results

Estimation results for equation aiinvest:
aiinvest = aiinvest.l1 + employlaborfdi.l1 + GDP.l1 + Governancequality.l1 + Governancestab.l1 + const

variables	estimate	Std.Error	t-value	Pr (>|t|)
aiinvest.l1	-0.17550	0.57924	-0.303	0.774
employlaborfdi.l1	0.54459	0.56426	0.965	0.379
GDP.l1	0.22780	0.18062	1.261	0.263
Governancequality.l1	0.23836	0.50633	0.471	0.658
Governancestab.l1	-0.08428	0.27957	-0.301	0.775
const	-0.24909	0.17136	-1.454	0.206

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
Residual standard error: 0.3263 on 5 degrees of freedom
Multiple R-Squared: 0.9473, Adjusted R-squared: 0.8946
F-statistic: 17.97 on 5 and 5 DF, p-value: 0.003272

Estimation results for equation employlaborfdi:
employlaborfdi = aiinvest.l1 + employlaborfdi.l1 + GDP.l1 + Governancequality.l1 + Governancestab.l1 + const

variables	estimate	Std.Error	t-value	Pr (>|t|
aiinvest.l1	-0.3462	0.3956	-0.875	0.4216
employlaborfdi.l1	-1.3107	0.3854	-3.401	0.0192 *
GDP.l1	-0.4545	0.1234	-3.684	0.0142 *
Governancequality.l1	1.0194	0.3458	2.948	0.0320 *
Governancestab.l1	0.3098	0.1910	1.622	0.1657
const	0.3971	0.1170	3.393	0.0194 *

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
Residual standard error: 0.4777 on 5 degrees of freedom
Multiple R-Squared: 0.8509, Adjusted R-squared: 0.7019
F-statistic: 5.708 on 5 and 5 DF, p-value: 0.03938

Estimation results for equation GDP:
GDP = aiinvest.l1 + employlaborfdi.l1 + GDP.l1 + Governancequality.l1 + Governancestab.l1 + const

variables	estimate	Std.Error	t-value	Pr (>|t|)
aiinvest.l1	0.5776	1.1567	0.499	0.639
employlaborfdi.l1	0.9181	1.1267	0.815	0.452
GDP.l1	-0.3845	0.3607	-1.066	0.335
Governancequality.l1	-1.1375	1.0110	-1.125	0.312
Governancestab.l1	-0.5460	0.5583	-0.978	0.373
const	-0.2727	0.3422	-0.797	0.462

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
Residual standard error: 0.9539 on 5 degrees of freedom
Multiple R-Squared: 0.5806, Adjusted R-squared: 0.1613
F-statistic: 1.385 on 5 and 5 DF, p-value: 0.3649

Estimation results for equation Governancequality:
Governance quality = aiinvest.l1 + employlaborfdi.l1 + GDP.l1 + Governancequality.l1 + Governancestab.l1 + const

variables	Estimate	Std. Error	t value	Pr(>|t|)
aiinvest.l1	0.558956	0.783354	0.714	0.507
employlaborfdi.l1	-0.150203	0.763091	-0.197	0.852
GDP.l1	0.205651	0.244271	0.842	0.438
Governancequality.l1	0.661238	0.684743	0.966	0.379
Governancestab.l1	-0.363167	0.378082	-0.961	0.381
const	0.005013	0.231742	0.022	0.984

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
Residual standard error: 0.646 on 5 degrees of freedom
Multiple R-Squared: 0.7887, Adjusted R-squared: 0.5773
F-statistic: 3.732 on 5 and 5 DF, p-value: 0.08736

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Estimation results for equation Governancestab: Governancestab = aiinvest.l1 + employlaborfdi.l1 + GDP.l1 + Governancequality.l1 + Governancestab.l1 + const				
variables	Estimate	Std. Error	t value	Pr(>|t|)
aiinvest.l1	-0.01725	1.12767	-0.015	0.988
employlaborfdi.l1	-0.77919	1.09850	-0.709	0.510
GDP.l1	-0.16563	0.35164	-0.471	0.657
Governancequality.l1	0.40301	0.98571	0.409	0.700
Governancestab.l1	0.25795	0.54426	0.474	0.656
const	0.28782	0.33360	0.863	0.428
Residual standard error: 0.93 on 5 degrees of freedom Multiple R-Squared: 0.5594, Adjusted R-squared: 0.1189 F-statistic: 1.27 on 5 and 5 DF, p-value: 0.3998				

Covariance matrix of residuals:					
variables	aiinvest	employlaborfdi	GDP	Governancequality	Governancestab
aiinvest	0.106461	-0.005822	0.06533	0.19216	-0.12039
employlaborfdi	-0.005822	0.228205	-0.25227	0.02356	-0.04262
GDP	0.065330	-0.252273	0.90994	0.13901	0.61282
Governancequality	0.192162	0.023558	0.13901	0.41737	-0.16804
Governancestab	-0.120394	-0.042624	0.61282	-0.16804	0.86490

Correlation matrix of residuals:					
variables	aiinvest	employlaborfdi	GDP	Governancequality	Governancestab
aiinvest	1.00000	-0.03735	0.20990	0.91162	-0.39676
employlaborfdi	-0.03735	1.00000	-0.5536	0.07633	-0.09594
GDP	0.20990	-0.55361	1.00000	0.22556	0.69078
Governancequality	0.91162	0.07633	0.2256	1.00000	-0.27969
Governancestab	-0.39676	-0.09594	0.6908	-0.27969	1.00000

Source : Author computation

4.2.5 Testing VAR (residual autocorrelation- normality test-stability)

Table 9 shows the test on the VAR model for residual autocorrelation and distribution computed in R functions:

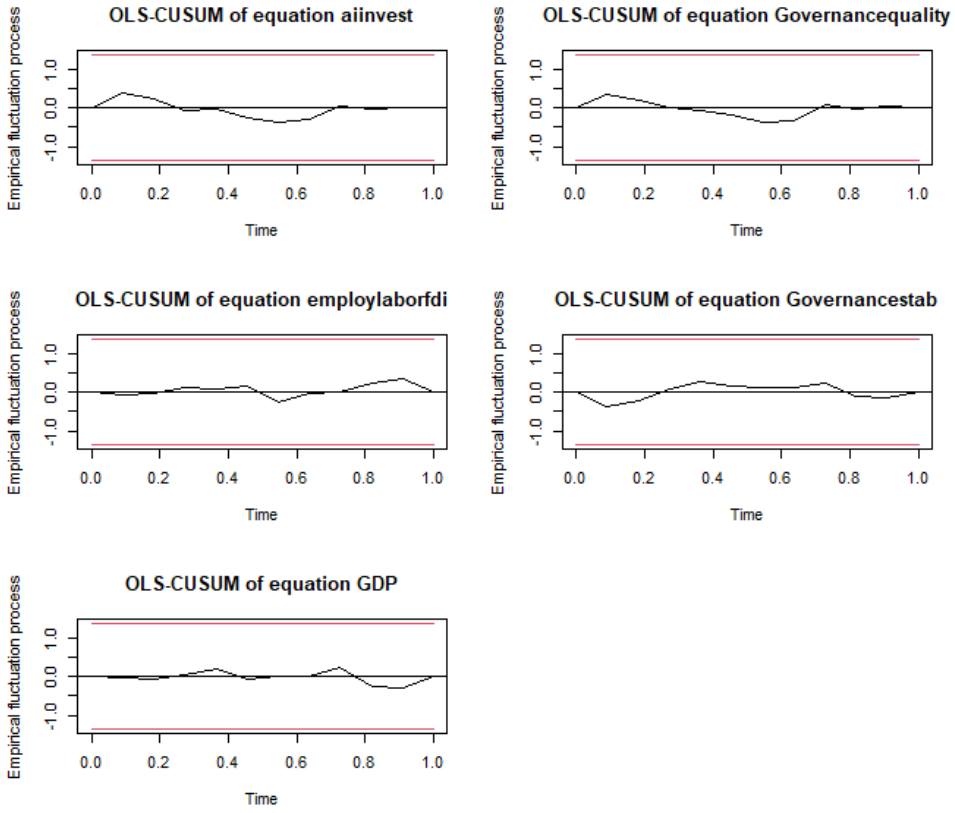
Table 9: Testing VAR

Test	p-value	Interpretation
PT-asymptotic	p-value < 2.2e-16	Le test pt.asymptotic: p-value>0.05; accept H0 (no autocorrelation in model) the errors is correlated in model
Jb-test	p-value = 0.9474	p-value>0.05; accept H0 (residuals have normal distribution)
skewness	p-value = 0.7587	
kurtosis	p-value = 0.9264	

Source: Author computation

Figure 6 shows, the OLS-CUSUM test that coefficient are stable in regression model at long run. Thereby, the model is available.

Figure 6: OLS-CUSUM test



Source: Author computation

4.2.6 Granger causality

Table 10: the result of Granger causality between variables in VAR (MAROC) model:

Data	p-value	Interpretation
Var (Maroc)= H0 :no instaneous causality between Governancequality and aiinvest employlaborfdi GDP Governancestab	0.2792	p-value>0.05 no granger causality between variables found in long run times. Which means that each variable do not grange cause the other variable in time. (lutkepohl 1996, Burda 1997,Dufour et al,2006)
Var (Maroc)= H0: No instantaneous causality between: GDP and aiinvest employlaborfdi Governancequality Governancestab	0.2506	
VAR (MAROC)= H0: No instantaneous causality between: employlaborfdi and aiinvest GDP Governancequality Governancestab	0.2866	
VAR (MAROC)= H0: No instantaneous causality between: Governancestab and aiinvest employlaborfdi GDP Governancequality	0.2539	
Var (Maroc)= H0: No instantaneous causality between: aiinvest and employlaborfdi GDP Governancequality Governancestab	0.2614	

Source: Author computation

4.3 SVAR Model

The variance decomposition plots (Figure 7) explain the representation of variables in VAR system. Firstly, For FEVD (*Aiinvest*) confirms that in a horizon of 10 years the part of *GDP* increase by the decrease of Governance and employment. Secondly, for FEVD

ISSN: 2658-8455
Volume 6, Issue 4 (2025), pp. 86-106.

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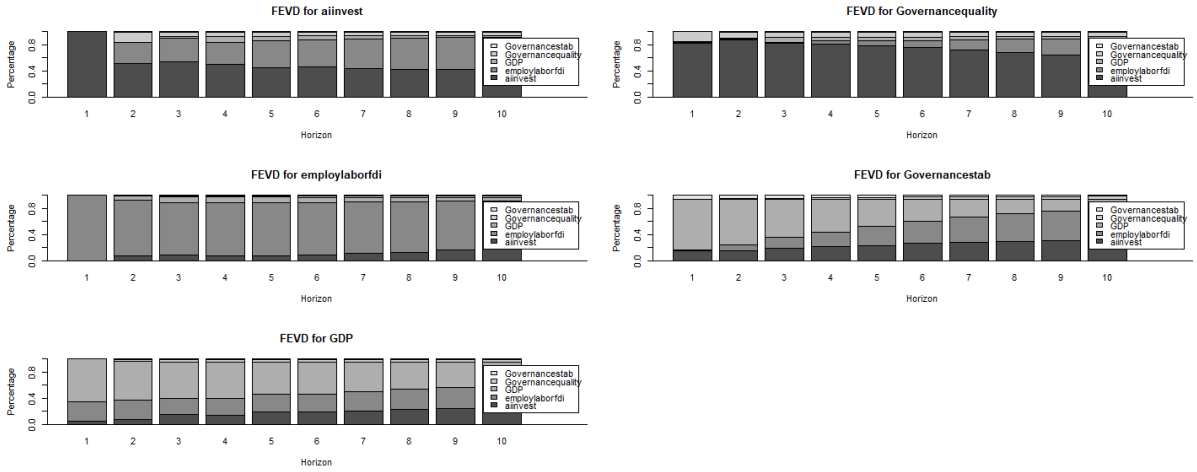
(*Governancequality*), the plot shows that the aiinvest referring to AI technologies can play a major role in developing governance context, and *GDP* increase up to sixth years. Thirdly, for FEVD (*employlaborfdi*), is explained by itself in 10 years and promoted by *Aiinvest* in 10%, which increase the lack of human resources qualified in AI technologies. Fourthly, FEVD (Governancestab) is explained in 10-year horizons increasingly by GDP and Governance quality, which mean that AI can strongly promote the Governance stability and GDP in short run term. At least, FEVD (GDP) is explained a half by GDP and Aiinvest which mean that AI technologies have significant impact on economic growth and governance in short term run on Moroccan territory.

Figure 7: variance decomposition



Source: Author computation

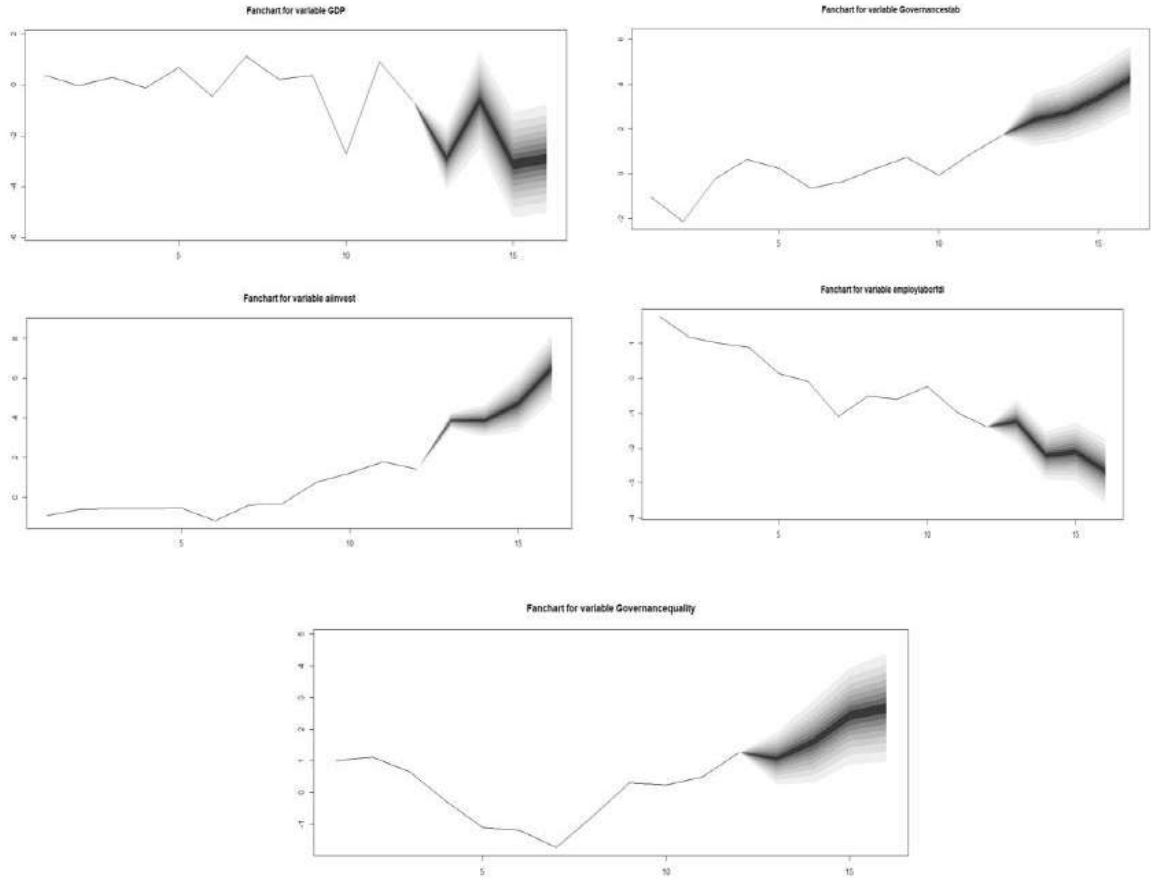
4.4 Forecasting VAR (MAROC):

The purpose of our study is to forecast VAR (Maroc) and conclude the behavior of variables in short run time based on their past.

The fanchart function plots show that the increase in AI investment projects implied a decrease in employments and increase in governance, either meaningful variations in economic growth and productivity.

To this extent, the prediction qualified in short run addresses the quality of the ability to invest in Moroccan territory as space green fields in digital processing. It adheres strongly to AI strategies despites the lack of human resources to invest in AI technologies, but significantly the data collected in the territory can be use under permission of law in commercial uses and concrete confidence safety and cybersecurity towards digital treats as well as e-signature, e-contract, and law of consumer.

Figure8: forecast fanchart



Source: Author computation

5. Conclusion

This study examines the impact of AI on Economic growth, productivity and Governance in data panel of 2011-2022 annually for Moroccan specificity, this period involves short-term dynamics under the limit of 1 to 2 lags to avoid overfitting. The results driven by VAR (1) analysis suggest the algorithmic path on variables selected by PCA analysis as represented one in Moroccan specificity. As we consider in the results section below, that AI has significant role on the governance indicators, economic growth and productivity. It made major changes on employment and Labor force and foreign direct investment. This side is critically involved by CESE in recommended action towards digital transition and promote AI projects for governance.

Policymakers should consider AI interventions in employment strategies and boost governance quality towards local actors. Furthermore, employment variable and labor force has significant estimated coefficient on AI and Governance showed in results. Which means that the integration of AI can improve employment patterns and refresh industries. It needs more infrastructures and materials dressing more opportunities for human resources qualified in AI high technologies. Despite the regulatory environment, Moroccan territory adhere to the implementation of AI in law. However, it encourages investments in AI technologies for the aim to perform productivities within digital services and facilitate commercial treaties.

For Moroccan state, this study reflect the algorithms of policies based on variables in past to forecast their impact in short run term. In Moroccan governement, the public policies and strategies are active in duration of six years. Whereas, AI strategies needs huge data collecting to drive systems and software in AI high technologies. The national Committee on knowledge

ISSN: 2658-8455
Volume 6, Issue 4 (2025), pp. 86-106.

IJAFAME
International Journal of Accounting, Finance, Auditing, Management & Economics

and information society CESE declare that AI has positive impact on economic growth and productivity around 30% in 2030, but human resources qualified to promote AI strategies are not sufficient to govern digital territory.

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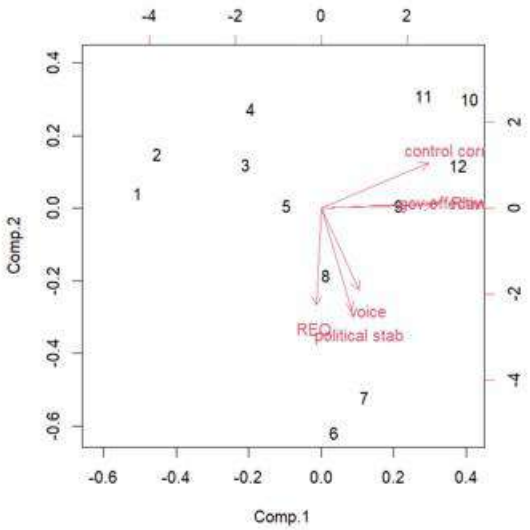
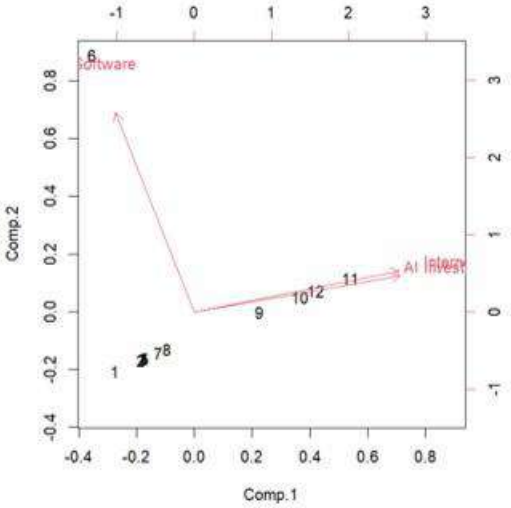
ISSN: 2658-8455
Volume 6, Issue 4 (2025), pp. 86-106.

Appendix 1

Bioplot 1 : governance



Bioplot 2 : AI trends



Bioplot 3 : economic growth and productivity