

Oil Price Shocks, Fiscal Asymmetry, and Digital Governance in MENA Economies: A Panel VAR Analysis

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ABSTRACT: The purpose of this paper is to examine the relationship between oil-price shocks, fiscal dynamics, and digital-governance readiness in twelve MENA economies over 2013–2024 using a first-difference Panel Vector Autoregressive (PVAR) model. The first-difference specification is adopted following the absence of evidence for a long-run cointegrating relationship among the integrated fiscal and digital-governance variables. Three main findings emerge. First, oil-price shocks constitute a major external driver of fiscal dynamics, accounting for approximately 29–30% of the forecast error variance of the fiscal balance across the horizons considered and approximately 25–31% of public-debt variance. Second, the transmission is strongly asymmetric across country groups. Among oil exporters, a 1% increase in Brent prices is associated with a 0.165-percentage-point increase in the fiscal balance ($p < 0.001$), whereas the corresponding coefficient for oil importers is statistically indistinguishable from zero ($+0.001$, $p = 0.915$). This contrast is consistent with the different fiscal transmission mechanisms associated with hydrocarbon revenues, energy-import costs, subsidies, inflation, and domestic economic activity. Third, digital-governance readiness, measured through an annual proxy based on the first principal component of internet penetration and WGI political stability, does not exhibit statistically significant Granger-predictive causality with fiscal outcomes at the annual frequency. The Granger-causality tests yield an F-statistic of 0.034 ($p = 0.853$) for digital governance predicting changes in the fiscal balance and 0.287 ($p = 0.593$) for the reverse direction. These results provide no evidence of a short-run predictive relationship between digital-governance readiness and fiscal-balance changes at the annual frequency. Finally, we construct a Budget Resilience and AI Index (BRAI) as a descriptive cross-sectional scorecard of the twelve MENA economies, combining fiscal resilience and digital readiness. Overall, the findings highlight the importance of oil-price exposure and country-specific fiscal structures in explaining short-run fiscal dynamics, while suggesting that the aggregate fiscal effects of digital-governance readiness may not be detectable at an annual frequency.

Keywords: Panel VAR, Oil price Shocks, MENA fiscal policy, Fiscal asymmetry, Digital Governance, Budget rigidity.

I. INTRODUCTION

Few economic relationships are as consequential for developing countries as the link between commodity prices and public finances. For MENA economies, a region characterized by either deep hydrocarbon dependency or significant energy import exposure, oil price movements represent the single most important source of exogenous fiscal variation. When Brent crude collapsed by 44.8% in 2015, fiscal balances across the region swung by as much as 10 to 15 percentage points of GDP [1, 2]. Conversely, the subsequent 78.6% rebound in 2021 illustrated the magnitude of fiscal exposure to large commodity-price movements and underscored the continuing importance of structural fiscal buffers and institutional capacity in managing external shocks. In tandem, there is an emerging consensus regarding what prescription to adopt: AI and digital government technology could act as shock absorbers for governments. Both the AI Preparedness Index (AIPI) of the

International Monetary Fund (IMF) from 2024 and the E-Government Development Index (EGDI) of the United Nations (UN) assume a causality link: countries that are more technologically advanced cope better with budgeting processes.

This paper subjects both the oil-fiscal channel and the digital governance hypothesis to systematic empirical scrutiny using a Panel VAR framework on twelve MENA economies from 2013 to 2024. Our methodology addresses three methodological issues overlooked in prior work. First, we replace the biennially published EGDI with an annual digital governance proxy, the first principal component of internet penetration and WGI political stability, constructed to avoid mechanically interpolating non-observed data points, which can artificially increase persistence and reduce effective variation in the series. Second, we implement bootstrap-based Westerlund's [3] cointegration testing appropriate for $T = 12$, which does not confirm a long-run relationship among the panel variables, motivating a PVAR specification in first differences. Third, we estimate the heterogeneous effect of the transmission of oil prices to importers versus exporters by subgroups.

Here, there are three takeaways. First, oil prices contribute to about 29-30% of fiscal balances' forecast error variance regardless of horizon, approximately thrice as much as any other advanced economy average would suggest. Second, there is a marked asymmetry here, the oil price shock-fiscal performance relationship is significantly strong among the exporters ($\beta = +0.165$, $p < 0.001$), while it does not exist for importers ($\beta = +0.001$, $p = 0.915$). Finally, digital readiness of the fiscal institutions does not Granger cause fiscal outcomes yearly in any direction, prescriptive recommendations do not hold.

These insights carry implications for fiscal policy formulation. Given the absence of empirical validation for a digital impact on fiscal performance at annual frequency, any AI-driven fiscal management strategy should not be regarded as immediate fiscal buffer for the coming year. For Morocco, and more broadly for the four-country oil-importer subgroup considered in our analysis, the main policy challenge is to insulate fiscal performance from oil-price fluctuations through institutional reforms rather than relying primarily on technological investments. Extending this conclusion to other oil-importing MENA economies would require country-specific evidence beyond the scope of this study insulating fiscal performance from the oil cycle requires institutional reforms, not technological investments. Our BRAI Index shows the gap between the structure of the two regions, whereby Gulf countries with high levels of fiscal health and technological infrastructure, have an advantage over those which lack these two features. This paper is organized as follows: Section 2 introduces three stylized facts. Section 3 outlines our model. Section 4 describes data and methodology. Section 5 provides the results of our empirical analysis. Section 6 discusses the policy implications, with particular attention to Morocco.

II. THREE MOTIVATING STYLIZED FACTS

The stylized facts below emerge directly from our panel data. In contrast to general observations, these stylized facts have numerical significance and can be tested by our econometric model.

Fact 1: MENA Fiscal Positions Are Structurally Divided by Oil Status

On the one hand, our sample demonstrated that fiscal balances of oil exporters had positive values (+1.9% of GDP) between 2012 and 2024. Fiscal balances of oil importers had negative averages (-7.0%) per year ($\sigma = 3.0$ pp). The difference between these figures is 9 pp, reflecting the structural deficit in regional fiscal institutions. On the other hand, the annual percentage change in the Brent crude oil price changed between -44.8% (2015) and 78.6% (2021) with the standard deviation being 33.2 pp. These figures suggest that there is considerable volatility affecting at least three major parameters, the oil incomes, subsidies, and growth.

Fact 2: Digital Governance Does Not Co-Move with Fiscal Outcomes at Annual Frequency

Although there is substantial literature on digital governance as a tool for fiscal governance, DIGI_ANNUAL does not seem to have any significant relationship with changes in the fiscal balance variable in the panel framework. These results are confirmed through panel Granger causality test, as DIGI_ANNUAL does not Granger cause Δ FISCAL_BAL ($F = 0.034$, $p = 0.853$), not does Δ FISCAL_BAL Granger-cause DIGI_ANNUAL ($F = 0.287$, $p = 0.593$). This result is supported by FEVD, which shows that accounts for approximately 0.0% of the forecast-error variance in Δ FISCAL_BAL at all horizons. This is not simply due to low statistical power, as the sample size consists of twelve countries for twelve years.

Fact 3: Oil Shock Transmission Is Asymmetric Across Country Types

The effect of oil price shocks differs substantially across country groups. The association between Brent price changes and fiscal balance changes is strongly positive among oil exporters ($\beta = +0.165$, $p < 0.001$), whereas it is

statistically indistinguishable from zero among oil importers ($\beta = +0.001$, $p = 0.915$). This asymmetry motivates Hypothesis H2 and suggests that the aggregate MENA relationship is largely driven by oil-exporting economies.

III. THEORETICAL FRAMEWORK AND HYPOTHESIS

Our theoretical model can be constructed via the following process: first we are developing the understanding of fiscal transmission of oil shocks by taking into account the notion of fiscal architecture; second, we are treating the potential of digital governance as a structural rather than cyclical fiscal factor; and third generating three hypotheses.

1. OIL PRICE SHOCKS AND FISCAL ARCHITECTURE IN MENA

Oil price shocks in MENA countries affect fiscal balance through an institutional framework that is completely different from exporters versus importers. Exporters face a situation where oil revenues represent a budget item, resulting in a near-direct connection between the price of oil and fiscal balances. Importers, in contrast, face an indirect mechanism where increasing oil prices raise both the cost of subsidies and the burden on the current account, but also contribute to higher inflation, reducing real incomes and economic growth, thus depressing tax revenues. The net impact of such a shock is ambiguous for importers due to the relative importance of each channel mentioned above, as noted in Fact 3. This asymmetry echoes recent panel-VAR evidence from the GCC bloc, where Sadraoui and Mili [4] document that fiscal balances and government expenditure react to oil price volatility with a speed and persistence that vary systematically with a country's degree of revenue diversification.

Fountain's [5] technology-enactment framework also provides a useful institutional perspective for understanding fiscal asymmetry across MENA economies. The framework emphasizes that the effects of external shocks are mediated by the organizational structures, institutional arrangements, and administrative capacities through which they are enacted. In the context of oil-price shocks, this perspective implies that identical changes in international oil prices may generate different fiscal responses depending on the underlying revenue structures and budgetary institutions of exporting and importing economies. Oil exporters incorporate hydrocarbon revenues directly into government budgets, creating a relatively immediate transmission from changes in oil prices to fiscal balances. Importing economies, by contrast, experience oil-price shocks primarily through expenditure pressures, subsidy costs, inflation, and associated effects on domestic economic activity and tax revenues. The institutional and fiscal structures through which the shock is transmitted therefore provide a theoretical basis for expecting asymmetric fiscal responses across exporter and importer groups.

This pattern is consistent with the classic theory of fiscal procyclicality in commodity-exporting economies. Talvi and Végh [6] show that governments in resource-dependent economies face strong political pressure to spend windfall revenue rather than smooth it over the cycle, since running a budget surplus during a boom carries a high political cost. Kaminsky, Reinhart, and Végh [7] describe the resulting pattern as a "when it rains, it pours" phenomenon, whereby procyclical fiscal policy amplifies rather than dampens the underlying commodity cycle, while Tornell and Lane [8] attribute part of this behaviour to a "voracity effect," in which competing political groups overappropriate windfall revenue during booms. Marioli and Végh [9] provide the first systematic quantification of this amplification mechanism across commodity exporters, and closely related recent evidence for the Gulf region reinforces the asymmetric pattern documented here: Çiçekçi and Gaygısız [10] find that fiscal procyclicality persists among oil-rich countries even where sovereign resource funds exist, while AlMarzoqi, Ben Tahar, and Ben Slimane [11], using a nonlinear ARDL framework on Saudi Arabia, show that government expenditure responds asymmetrically to oil price shocks, rising sharply during booms without falling proportionately during busts. Marioli and Vasishtha [12] extend this evidence to a broader panel of commodity-exporting emerging and developing economies, confirming that the degree of procyclicality is itself shaped by institutional quality and fiscal buffers. Taken together, this literature situates our fiscal asymmetry hypothesis (H2) within an established theoretical tradition rather than treating it as an ad hoc empirical regularity.

However, there is an important consequence of this institutional structure concerning the use of AI fiscal tools. While scenario simulation and predictive analytics can provide better foresight, this will not influence the nature of fiscal revenue in the country. If a country relies on oil imports rather than revenues, it makes little difference how good its AI fiscal tool becomes.

2. DIGITAL GOVERNANCE AS A STRUCTURAL INPUT, NOT A CYCLICAL BUFFER

Current literature on AI and public finance [13, 14] often characterizes digital governance as a source of efficiency gains with budgetary dividends in the short to medium term. Recent GCC-focused evidence reinforces this expectation at the microeconomic level: Nomran et al. [15] find that more advanced electronic government systems are associated with lower effective tax burdens for firms, while Rezaei and Jablonsky [16] show that digital technologies improve tax-collection efficiency across a panel of emerging economies, suggesting that digital dividends operate mainly through administrative channels rather than through aggregate fiscal balances. Our theoretical approach takes a different view based on the dynamic capabilities approach to firm development [17]: digital governance capabilities are inputs that require several years of development through platform, information system, and process investment along with training of the human capital stock.

On the proposed conception, the failure of digital governance to show budgetary dividends in the short run is neither surprising nor indicative of a flaw. The annual panel data time series does not cover the incubation period during which digital governance capabilities are developed. The recommendation that governments “deploy AI” to gain fiscal resilience conflates two separate processes for long-term investment in building digital capabilities (the investment story) and its use to manage budgets (the operations story). The model tested in this paper addresses the latter and finds no evidence for it.

This distinction has a well-established theoretical anchor. Fountain’s [5] technology enactment framework argues that information technologies are never adopted in a vacuum: their effects are “enacted” through the existing organizational forms and institutional logics of the bureaucracy that deploys them, so identical technologies can produce very different, and sometimes negligible, organizational outcomes depending on the institutional context in which they are embedded. Applied to our setting, this implies that digital governance tools introduced into MENA fiscal administrations should not be expected to generate uniform, mechanical improvements in budgetary outcomes: their fiscal payoff is conditional on complementary institutional capacity that annual panel data of this length cannot fully capture. This theoretical caveat is consistent with the muted, inconclusive digital governance coefficients that we report below and motivates H3 as a genuine empirical question rather than a foregone conclusion.

3. TESTABLE HYPOTHESES

Given the theory that has been developed above, the following hypothesis is suggested for empirical testing under the Panel Var framework:

H1 (Oil Shocks Transmission Hypothesis): Shocks to Brent crude oil prices Granger-cause movements in fiscal balances and public debts in the MENA panel, explaining a significantly larger fraction of the forecast error variance compared to advanced economies.

H2 (Fiscal Asymmetry Hypothesis): The fiscal impact of oil price shocks is significantly larger for oil exporters than for importers, with the full-panel coefficient dominated by the exporter group.

H3 (Digital Governance Null Hypothesis): Digital governance readiness, measured through an annual proxy free from interpolation bias, does not Granger-cause fiscal balance changes or capital expenditure ratios at annual frequency in the MENA panel.

4. DATA AND ECONOMETRIC METHODOLOGY

4.1. Sample and Data Sources

The panel comprises twelve MENA economies over 2012–2024: Saudi Arabia, UAE, Qatar, Kuwait, Oman, and Bahrain (net oil exporters); Morocco, Tunisia, Egypt, and Jordan (net oil importers); Algeria and Iraq (hybrid economies with significant but not dominant hydrocarbon sectors). The panel is balanced. The effective PVAR sample covers 2013–2024 ($T = 12$ after first differencing), yielding $NT = 132$ effective observations.

Table 1. Variable Definitions, Sources, and Transformation.

Variable	Definition	Description and Transformation	Sources	Period
BRENT_SHOCK	Annual percentage change in Brent crude oil price	Annual % change in Brent crude price (USD/barrel). Level variable: confirmed $I(0)$ by ADF (t -stat = -3.028 ; $CV5\% = -3.00$).	U.S. EIA	2012–2024

Δ FISCAL_BAL	Net lending/borrowing of general government	First difference of net lending/borrowing, General Government (% GDP).	IMF WEO Oct. 2025	2013–2024
Δ CAPEX_RATIO	Government capital expenditure ratio (GTC / total expenditure)	First difference of GCF / Total Government Expenditure ratio.	IMF WEO (computed)	2013–2024
Δ DEBT_GDP	Gross Government	First difference of gross government debt (% GDP).	IMF WEO	2013–2024
Δ DIGI_ANNUAL	Digital governance proxy (see below)	First difference of DIGI_ANNUAL (defined below). Annual digital proxy.	World Bank WDI + WGI	2013–2024
DIGI_ANNUAL	First principal component of internet penetration (%) and political stability index (WGI)	First principal component of internet penetration (%) and WGI Political Stability index (0–100). Annual frequency, 100% complete. Var. explained: 83.2%. $r(\text{EGDI}) = 0.717$.	World Bank WDI/WGI	2012–2024
Controls	Macroeconomic control variables: GDP per capita, inflation, trade openness, government effectiveness	Log GDP per capita (USD), GDP deflator inflation (%), merchandise trade openness (% GDP), government effectiveness (WGI 1–10).	World Bank WDI/WGI	2012–2024

Note: All I(1) variables (FISCAL_BAL, CAPEX_RATIO, DEBT_GDP, DIGI_ANNUAL) confirmed by CIPS test ([18]) and entered in first differences. BRENT_SHOCK is country-invariant; standard ADF applied to annual time series ($T=13$). CD test ([19]) rejects H_0 of no cross-sectional dependence for all variables ($p < 0.001$), motivating CIPS over IPS.

All fiscal variables in the analysis are obtained from the October 2025 vintage of the IMF World Economic Outlook (WEO). The 2024 observations for the twelve countries are classified by the IMF as staff estimates rather than final fiscal outturns, whereas 2025 observations, which are not used in the analysis, correspond to projections. The 2024 estimates are retained because excluding the latest available year would further reduce the already limited time dimension of the panel. Moreover, the WEO estimates incorporate information from national budget execution and other official sources available at the time of compilation and are subject to subsequent revisions as final fiscal accounts become available. Given the short time dimension of the panel, retaining 2024 therefore provides a useful balance between sample length and data completeness.

The potential influence of the 2024 estimates is further examined through the temporal stability of the main results. The comparison between the 2013–2018 and 2013–2024 specifications reported in Table 8 shows that the principal oil–fiscal relationship remains qualitatively unchanged when the later observations are included. This supports the interpretation that the main finding is not solely attributable to the inclusion of the estimated 2024 observations.

4.2. The Annual Digital Governance Proxy

A central methodological contribution of this paper is the replacement of the biennially published E-Government Development Index (EGDI) with an annual digital governance proxy. The EGDI is published every two years by UN DESA; mechanical linear interpolation of the missing odd-year observations creates artificial persistence in the series, reduces effective variance by 50–80%, and, as shown in our results, can generate spurious Granger causality relationships attributable to the smoothing algorithm rather than economic fundamentals.

Rather than mechanically interpolating missing annual observations, we construct DIGI_ANNUAL from two annually available indicators: internet penetration, measured as the percentage of individuals using the Internet, and the World Governance Indicators (WGI) measure of Political Stability and Absence of Violence. The first principal component explains 83.2% of the joint variance of these two indicators. We interpret DIGI_ANNUAL as an institutionally adjusted digital-readiness proxy rather than as a direct measure of digital governance. Its correlation with the biennial EGDI ($r = 0.717$) provides supporting evidence of construct relevance, while its annual construction preserves the observed year-to-year variation in the underlying indicators.

4.3. Unit Root, Cross-Sectional Dependence, and Cointegration Tests

Cross-sectional dependence is common in MENA panel data, as countries are exposed to common oil price shocks, regional financial cycles, and institutional developments. The Pesaran [19] CD test rejects the null hypothesis

of cross-sectional independence for all panel variables ($p < 0.001$), confirming the presence of significant cross-sectional dependence. This result motivates the use of the cross-sectionally augmented IPS (CIPS) test developed by Pesaran [18], which incorporates cross-sectional averages into the underlying ADF regressions and is therefore more appropriate in the presence of cross-sectional dependence.

Table 2. Unit Root and Cross-Sectional Dependence Tests.

Variable	Test	Statistic	Critical	Order	Decision
BRENT_SHOCK	ADF	-3.028	-3.00	I(0) *	Stationary (weak significance)
BRENT_SHOCK	KPSS (Constant, Newey-West)	0.171	0.347	I(0)	Fail to reject H0 (Stationary)
Δ BRENT_SHOCK	ADF, first difference	-4.523	-3.233	I(0)	Stationary at 5%
FISCAL_BAL	Cross-sectionally Augmented IPS (CIPS)	-1.971	-2.60	I(1)	Non-stationary
Δ FISCAL_BAL	CIPS First Difference	-3.412	-2.60	I(0)	Reject H0 at 1% (Stationary)
CAPEX_RATIO	CIPS	-1.640	-2.60	I(1)	Non-stationary
Δ CAPEX_RATIO	CIPS First Difference	-3.155	-2.60	I(0)	Reject H0 at 1% (Stationary)
DEBT_GDP	CIPS	-2.202	-2.60	I(1)	Non-stationary
Δ DEBT_GDP	CIPS First Difference	-3.580	-2.60	I(0)	Reject H0 at 1% (Stationary)
DIGI_ANNUAL	CIPS	-0.827	-2.60	I(1)	Non-stationary
Δ DIGI_ANNUAL	CIPS First Difference	-2.994	-2.60	I(0)	Reject H0 at 5% (Stationary)
All variables	Cross-sectional dependence test	-	-	-	Dependence confirmed ($p < 0.001$)

Notes: CIPS augmented with cross-sectional mean and lag ([18]). Critical values for $T=13$ interpolated from Pesaran [18] Table IIb. ADF applied to annual time series of BRENT_SHOCK ($T=13$, MacKinnon 1996 critical values). * $p < 0.10$.

We report additional unit-root diagnostics, BRENT_SHOCK is defined as the annual percentage change in Brent crude oil prices; because it is constructed as a percentage first difference of the underlying I (1) price level, it is expected to be I (0) by econometric design. Table 2 reports the full test specification: an ADF test with a constant term (no trend), lag order $p = 1$ selected by the Schwarz () information criterion over the candidate range $p = 0-4$ ($t = -3.028$, MacKinnon 1996 critical values for $T = 13$), together with a complementary KPSS test (constant, automatic Newey-West bandwidth; statistic = 0.171, 10% critical value = 0.347). Both tests support treating BRENT_SHOCK as I(0). Given the short time-series dimension ($T = 13$), these unit-root and stationarity tests necessarily have reduced asymptotic power, so we report them as complementary evidence consistent with the variable's construction rather than as definitive proof of its order of integration.

As an additional robustness check, the first difference of BRENT_SHOCK was also tested for stationarity using an ADF specification with a constant term. The test statistic is -4.523 , which is more negative than the 5% critical value of -3.233 , confirming stationarity after first differencing. This additional result is consistent with the treatment of BRENT_SHOCK as a stationary shock measure in the empirical analysis.

The CIPS results indicate that FISCAL_BAL, CAPEX_RATIO, DEBT_GDP, and DIGI_ANNUAL are non-stationary in levels but become stationary after first differencing, supporting their classification as I (1) variables. BRENT_SHOCK is treated separately because it is common to all countries; therefore, a standard ADF test is applied to its annual time series. These results justify the use of first differences for the I (1) variables in the subsequent PVAR estimation.

Cointegration is assessed using the bootstrap panel cointegration procedure of Westerlund and Edgerton [20], alongside the underlying Westerlund [3] framework. This error-correction-based approach is preferred here over residual-based panel cointegration tests such as Pedroni [21], because the error-correction framework directly tests the hypothesis of interest (whether fiscal variables adjust toward a long-run equilibrium with oil prices) rather than only detecting the presence of a stable long-run relationship. The bootstrap procedure is particularly relevant in our setting because the panel has a short time dimension and exhibits cross-sectional dependence. Rather than relying exclusively on asymptotic critical values, the bootstrap approach generates an empirical reference distribution and provides bootstrap p-values that are more appropriate for the finite-sample setting considered here.

The bootstrap panel error-correction cointegration test follows the Westerlund [3] framework and is operationalized using the procedure developed by Persyn and Westerlund [22]. The methodological framework is complemented by the bootstrap approach of Westerlund and Edgerton [20], which is particularly suitable when cross-sectional dependence and a short time dimension may affect conventional asymptotic inference.

4.4. PVAR Specification

We estimate a mixed-integration PVAR (1) of the form:

$$Y_{(i,t)} = A_0 + A_1 Y_{(i,t-1)} + f_i + \varepsilon_{(i,t)} \quad (1)$$

where the endogenous vector defined as:

$$Y_{(i,t)} = [\Delta \text{BRENT_SHOCKS}_{(i,t)}, \Delta \text{FISCAL_BAL}_{(i,t)}, \Delta \text{CAPEX_RATIO}_{(i,t)}, \Delta \text{DEBT_GDP}_{(i,t)}, \Delta \text{DIGI_ANNUAL}_{(i,t)}]. \quad (2)$$

Country fixed effects are eliminated through within-group demeaning. The lag order $p=1$ is selected according to the Schwarz Bayesian Information Criterion (BIC), which attains its minimum at $p=1$ among the candidate specifications $p=1,2,3$. Standard errors are obtained from 500 bootstrap replications using country-block resampling.

Among the candidate specifications ($p=1,2,3$), the BIC values are -12.450 , -10.120 , and -8.510 , respectively. Since the minimum BIC value is obtained for ($p=1$), the one-lag specification is retained for the baseline PVAR model. Structural identification relies on the recursive Cholesky decomposition of the innovation covariance matrix Σ , with the following ordering: Energy shock, Fiscal balance, Investment ratio, Public debt, and Digital governance.

The recursive ordering BRENT_SHOCK, $\Delta \text{FISCAL_BAL}$, $\Delta \text{CAPEX_RATIO}$, $\Delta \text{DEBT_GDP}$, and DIGI_ANNUAL reflects an economic assumption regarding the relative speed of contemporaneous adjustment across the variables. BRENT_SHOCK is placed first because international oil prices are determined globally and individual MENA economies are too small to affect the Brent price contemporaneously. ($\Delta \text{FISCAL_BAL}$) is ordered second because government revenues and current expenditures can respond to oil-price movements within the same fiscal year through automatic fiscal mechanisms. ($\Delta \text{CAPEX_RATIO}$) follows because capital expenditure is generally subject to annual budget planning and administrative implementation lags. ($\Delta \text{DEBT_GDP}$) is placed fourth because changes in the public-debt ratio reflect the accumulation of fiscal imbalances and therefore adjust more gradually than fiscal flows. Finally, (DIGI_ANNUAL) is ordered last because digital-governance capacity represents a relatively persistent institutional state variable that evolves through investment, institutional reform, and administrative adaptation over longer horizons rather than within a single fiscal year. This recursive, small-open-economy identification follows standard practice in the structural VAR literature on commodity-price transmission, where the price of an internationally traded commodity is treated as predetermined with respect to the smaller economies that receive its shocks [23].

This recursive ordering is consistent with the theoretical sequencing developed in Section 3. Its sensitivity is further assessed in Section 6 using alternative recursive orderings. The FEVD results reported in Table 8 (row 1) show that the magnitude of the Brent-to-fiscal channel varies by less than one percentage point across the four alternative orderings ($29.4\% \pm 0.8$ percentage points), indicating that the main substantive conclusion is not driven by the specific recursive sequencing adopted in the baseline model.

The relatively small dimensions of the panel ($N=12$ countries and $T=12$ years) warrant particular caution regarding statistical inference, robustness, and generalizability. Given the short time dimension, the asymptotic properties of panel unit-root, cointegration, and PVAR procedures may provide only an approximation to the finite-sample distribution of the estimators. To mitigate this limitation, the analysis employs cross-sectional-dependence-robust procedures, including the CIPS test, together with bootstrap-based inference based on 500 country-block replications. These methodological choices are intended to reduce reliance on conventional asymptotic approximations in the short- (T) setting. We further note that the pooled fixed-effects PVAR estimated here imposes common slope coefficients across countries; heterogeneous-panel alternatives such as the mean-group and pooled mean-group estimators of Pesaran and Smith [24] relax this assumption at the cost of additional parameters, which the present $N=12$, $T=12$ dimensions cannot support with adequate precision.

The cross-sectional dimension also limits the extent to which the estimated coefficients can be generalized beyond the countries included in the analysis. The sample consists of twelve MENA economies with sufficiently available fiscal and digital-governance data over the study period. Accordingly, the exporter, importer, and hybrid classifications should be interpreted as describing the dynamics observed within this specific panel rather than as estimates of universal population parameters. The leave-one-country-out robustness analysis reported in Table 8 (row

3) further indicates that the main result does not depend on the inclusion of a single country, as excluding individual countries does not alter the sign or statistical significance of the headline relationship.

Nevertheless, the limited (N) and (T) dimensions imply that the estimated coefficients should not be extrapolated mechanically to MENA economies outside the sample or to other commodity-exporting regions. The empirical findings should therefore be interpreted primarily as evidence concerning the structure of the oil–fiscal relationship within the twelve-country MENA panel, rather than as evidence of a universal structural elasticity.

IV. EMPIRICAL RESULTS

1. PVAR Coefficient MATRIX and System Stability

The maximum modulus of the eigenvalues of the companion matrix is 0.363, which is below unity and therefore confirms the stability of the estimated PVAR(1) system. This indicates that shocks to the system generate transitory rather than explosive dynamics, with deviations from the system's dynamic path tending to diminish over time.

Table 3. PVAR (1) Coefficient Matrix.

Regressor	$\Delta BRENT_SHOCK$	$\Delta FISCAL_BAL$	$\Delta CAPEX_RATIO$	$\Delta DEBT_GDP$	$\Delta DIGI_ANNUAL$
$\Delta BRENT_SHOCK_{(t-1)}$	0.319* (0.085)	0.069* (0.033)	0.000 (0.000)	-0.080** (0.026)	0.000 (0.000)
$\Delta FISCAL_BAL_{(t-1)}$	0.223 (0.523)	-0.035 (0.190)	-0.002 (0.001)	-0.072 (0.120)	0.000 (0.000)
$\Delta CAPEX_RATIO_{(t-1)}$	-30.572 (23.284)	2.380 (5.323)	-0.042 (0.125)	2.768 (4.097)	0.008 (0.024)
$\Delta DEBT_GDP_{(t-1)}$	2.175 (0.289)	0.325* (0.10)	0.001 (0.002)	-0.152 (0.129)	0.000 (0.001)
$\Delta DIGI_ANNUAL_{(t-1)}$	-48.705 (114.686)	-3.127 (25.584)	-0.131 (0.407)	4.943 (26.401)	-0.151 (0.092)
Observation (N)	132				
Max eigenvalue modulus	0.363				

Notes: Within-group OLS with individual fixed effects removed by demeaning. Bootstrap SE in parentheses (500 replications, country-block). *** p < 0.01; ** p < 0.05; * p < 0.10. System stable: max eigenvalue modulus = 0.363 < 1.

The positive coefficient on lagged $\Delta DEBT_GDP$ should not be interpreted as evidence that higher public debt mechanically improves the fiscal balance. Rather, it may reflect a lagged debt–fiscal adjustment dynamic: countries that experience an increase in debt in year $t-1$, for instance in response to an economic shock, may subsequently undertake fiscal consolidation in year t , resulting in an improvement in the fiscal balance. This is a within-country dynamic captured by the fixed-effects specification. Given its marginal statistical significance ($p < 0.10$), the coefficient should be interpreted cautiously as a lagged association rather than as evidence of a structural causal effect. Reverse causality and omitted dynamic mechanisms cannot be ruled out.

The lagged Brent shock ($\Delta BRENT_SHOCK_{(t-1)}$) has a positive and statistically significant effect on changes in the fiscal balance ($\beta = +0.069$, $p < 0.05$), consistent with the presence of an oil-revenue transmission channel in the MENA panel. The same shock has a negative and statistically significant effect on changes in public debt ($\beta = -0.080$, $p < 0.01$), suggesting that favorable oil-price movements may contribute to debt reduction through improved fiscal positions. Changes in the fiscal balance are also positively associated with lagged changes in public debt ($\beta = +0.325$, $p < 0.1$), although this marginally significant coefficient should be interpreted cautiously. By contrast, the coefficient associated with lagged digital governance is economically negligible and statistically insignificant across the system equations.

1.1. Granger Causality: Oil Shocks Dominate Short-Run Fiscal Dynamics

Table 4. Panel Granger Causality Tests.

Cause	Effect	F-statistic	p-value	Decision	Interpretation
BRENT_SHOCK	Δ FISCAL_BAL	12.382	0.0006	Yes ***	Strong evidence of predictive causality (H1 supported)
BRENT_SHOCK	Δ DEBT_GDP	11.045	0.0012	Yes ***	Strong evidence of predictive causality (H1 supported)
BRENT_SHOCK	Δ CAPEX_RA-TIO	0.162	0.6879	No	No evidence of causality (no direct investment channel)
Δ CAPEX_RA-TIO	Δ DIGI_AN-NUAL	0.091	0.7638	No	No evidence of causality
Δ DIGI_AN-NUAL	Δ FISCAL_BAL	0.034	0.8531	No	No evidence of causality
Δ FISCAL_BAL	Δ DIGI_AN-NUAL	0.287	0.5928	No	No predictive relationship detected

Notes: F-statistic for exclusion of first lag of cause variable from dependent equation. PVAR (1), N=12, T=12, 132 effective observations. *** $p < 0.01$.

Table 4 provides strong evidence that oil-price shocks contain significant predictive information for fiscal dynamics. Oil-price shocks Granger-cause changes in the fiscal balance ($F = 12.38$, ($p < 0.001$)) and changes in public debt ($F = 11.05$, ($p = 0.001$)), supporting H1. By contrast, the null hypothesis of no predictive causality from digital governance to changes in the fiscal balance cannot be rejected ($F = 0.034$, ($p = 0.853$)). The reverse direction is also statistically insignificant ($F = 0.287$, ($p = 0.593$)). Similarly, no statistically significant predictive relationship is detected between Brent shocks and changes in capital expenditure ($F = 0.162$, ($p = 0.688$)). Overall, the results indicate a dominant short-run oil-fiscal transmission mechanism, while providing no statistical evidence of direct capital-expenditure or digital-governance predictive channels at the annual frequency.

1.2. Asymmetric Transmission: Exporters vs Importers

Table 5. Subgroup Analysis: Brent (-1) and Δ Fiscal Bal Coefficient.

Country Group	Observation (N)	Coefficient β (BRENT _(t-1) ; Δ FISCAL_BAL)	Bootstrap SE	t-statistic	p-value	Statistical Significance
Full Panel (N=12)	132	0.069	0.033	2.09	0.038	**
Oil Exporters (N=6)	66	0.165	0.045	3.636	0.001	***
Oil Importers (N=4)	44	0.001	0.013	0.107	0.915	-

Separate PVAR (1) models are estimated for each subgroup using country-block bootstrap standard errors (200 replications). The results indicate a marked asymmetry between oil exporters ($\beta = +0.165$, $p < 0.001$) and oil importers ($\beta \approx 0$, $p = 0.915$). The full-panel coefficient (+0.069) is therefore consistent with the stronger response observed among exporters. Algeria and Iraq are classified as a hybrid subgroup and are not included in the subgroup dynamic estimation because this group comprises only two countries ($N = 2$; $NT = 22$). The subgroup analysis consequently covers six oil exporters ($NT = 66$) and four oil importers ($NT = 44$), representing 110 of the 132 total panel observations. The exporter/importer/hybrid classification is retained in the BRAI as a descriptive cross-sectional classification.

Table 5 supports H_2 and reveals a pronounced asymmetry in the fiscal response to oil-price shocks across producer groups. The full-panel coefficient (+0.069) masks a pronounced asymmetry among oil exporters, a 1 percentage point increase in the Brent price is associated a +0.165-percentage point improvement in the fiscal balance ($p < 0.001$). Among oil importers, the coefficient is +0.001 and statistically indistinguishable from zero. The importer estimate is small in magnitude ($\beta = 0.001$) and statistically insignificant ($p = 0.915$), providing no evidence of a systematic short-run fiscal response to Brent price changes within this subgroup. Given the small number of importing countries ($N=4$), however, this null result should be interpreted cautiously rather than as definitive evidence of the absence of an oil-price effect.

This pattern is consistent with offsetting fiscal channels: increased crude prices raise the costs of subsidies, lower disposable incomes, and depress growth-related taxes, all roughly balancing out at the fiscal level on an annual basis. This discrepancy holds important lessons for the analysis of the region. Research done on the MENA panel with no differentiated treatment based on oil producer status is thus examining the impact of being a crude exporter. In terms of Morocco, Tunisia, Egypt, and Jordan, being an oil importer means that changes in oil prices create fiscal burdens and not gains.

1.3. Impulse Response Functions

For Δ Fiscal Bal, the response to a positive Brent shock becomes positive from approximately ($h=2$) onward. This pattern is consistent with a positive transmission of oil-price shocks to fiscal conditions in the MENA panel. For Δ DEBT_GDP, the response to a positive Brent shock is negative over the reported horizons. This pattern is consistent with a reduction in public debt following an improvement in oil-related fiscal conditions.

Figure 1 – Impulse Response Functions: Response to a One-Standard-Deviation Positive Brent Price Shock | PVAR(1) in first differences | 90% Bootstrap CI (500 rep.) | N=12 MENA, 2013-2024

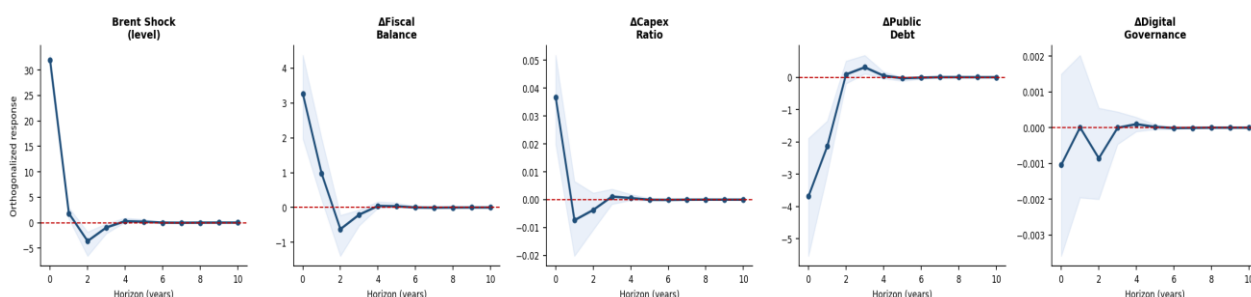


FIGURE 1. presents the orthogonalized impulse response functions from a one-standard-deviation positive Brent price shock, with 90% bootstrap confidence bands (500 replications).

For Δ DIGI_ANNUAL, the responses remain close to zero following a Brent shock. This result is consistent with the limited short-run response of digital governance to oil-price shocks.

Table 6. Forecast Error Variance Decomposition (FEVD), Selected Horizons.

Variable / Horizon	Brent Shock	Δ Fiscal Bal.	Δ Capex Ratio	Δ Public Debt	Δ Digital Gov.
Panel A. Variance Decompositon of Δ Fiscal					
Bal.					
h = 1	30.5%	69.5%	0.0%	0.0%	0.0%
h = 3	29.4%	60.3%	0.1%	10.2%	0.0%
h = 10	29.4%	60.1%	0.1%	10.3%	0.0%
Panel B. Variance Decompositon of Δ DEBT_GDP.					
h = 1	25.7%	3.8%	1.2%	69.3%	0.0%
h = 3	30.4%	3.5%	1.5%	64.6%	0.0%
h = 10	30.5%	3.5%	1.5%	64.5%	0.0%
Panel C. Variance Decompositon of Δ DIGI_ANNUAL.					
h = 1	0.0%	0.0%	0.0%	0.0%,	100.0%
h = 10	0.0%	0.1%	0.0%	0.0%	99.9%

Notes: Cholesky decomposition, ordering: BRENT_SHOCK, Δ FISCAL_BAL, Δ CAPEX_RATIO, Δ DEBT_GDP, Δ DIGI_ANNUAL. Rows sum to 100% (rounding). Bold: dominant driver at each horizon. PVAR (1), N=12, T=12.

Figure 2 – Forecast Error Variance Decomposition (FEVD)
PVAR(1) | Cholesky Identification | Panel MENA 12 countries, 2013–2024

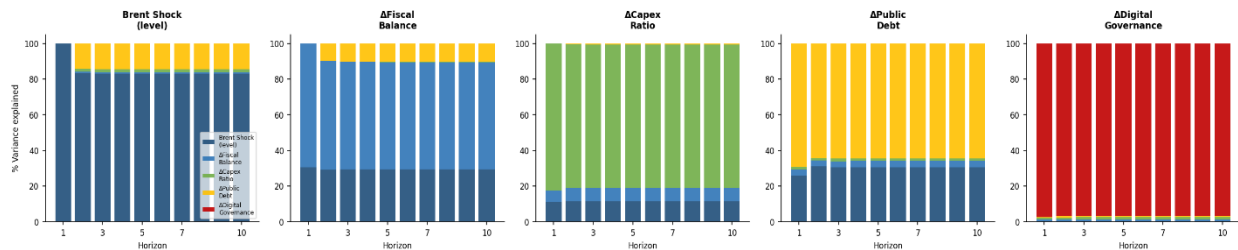


FIGURE 2. Forecast Error Variance Decomposition (FEVD): Share of Each Shock across 10 Horizons PVAR (1) | Cholesky Identification | N=12 MENA, 2013–2024

The FEVD results highlight two main findings. First, Brent shocks explain approximately 29–30% of the forecast-error variance of Δ Fiscal Bal, starting from the first horizon and remaining broadly stable over the ten-period horizon. This indicates that oil-price shocks represent an important source of variation in fiscal-balance dynamics. Second, Δ DIGI_ANNUAL contributes approximately 0.0% to the forecast-error variance of Δ Fiscal Bal across the reported horizons. This result is consistent with the Granger-causality results in Table 4, which do not detect a statistically significant short-run predictive relationship between digital governance and fiscal-balance changes.

1.4. BRAI Composite Index

Table 7. Budget Resilience and AI Index (BRAI): MENA Rankings.

Rank	Country	Country Group	Pillar I: Fiscal Resilience	Pillar II: Digital Readiness	BRAI Score
1	Kuwait	Exporter	1.000	0.870	0.935
2	UAE	Exporter	0.634	0.992	0.813
3	Qatar	Exporter	0.517	1.000	0.759
4	Saudi Arabia	Exporter	0.573	0.726	0.650
5	Oman	Exporter	0.450	0.804	0.627
6	Bahrain	Exporter	0.000	0.840	0.420
7	Morocco	Importer	0.261	0.561	0.411
8	Algeria	Hybrid	0.446	0.243	0.344
9	Tunisia	Importer	0.185	0.368	0.276
10	Jordan	Importer	0.015	0.502	0.259
11	Iraq	Hybrid	0.412	0.000	0.206
12	Egypt	Importer	0.012	0.219	0.115

Note: The baseline BRAI is constructed using a 67% weight for the fiscal-resilience pillar and a 33% weight for the digital-readiness pillar. An equal-weight specification (50/50) is examined as a robustness check in Table 8.

In the baseline specification, the fiscal-resilience pillar receives a weight of 67%, while the digital-readiness pillar receives a weight of 33%. This weighting reflects the primary objective of the index, namely to capture fiscal resilience, while recognizing the complementary role of digital readiness. However, because there is no a priori theoretical basis for assuming that fiscal resilience should receive twice the weight of digital readiness, we also assess an equal-weight specification. The 50/50 alternative is reported as a robustness check in Table 8. The resulting rank correlation between the baseline and equal-weight specifications is $\rho = 0.951$, indicating that the relative ranking of countries is highly robust to the weighting scheme.

It is clear from the BRAI index that there is a structural dichotomy, just like that which was seen in the panel analysis above. The top three countries in the MENA region are Kuwait, with an index of 0.935; United Arab Emirates (UAE), with an index of 0.813; and Qatar, with an index of 0.759, which not only have an advanced technological infrastructure but also are economically stable countries. Ranked seventh overall and first among oil-importing

countries, Morocco has a BRAI score of 0.411. Noteworthy about Morocco is the fact that it has a considerably higher Pillar II index (0.561) than Pillar I index (0.261). Rounding off the list is Egypt, with an index of 0.115.

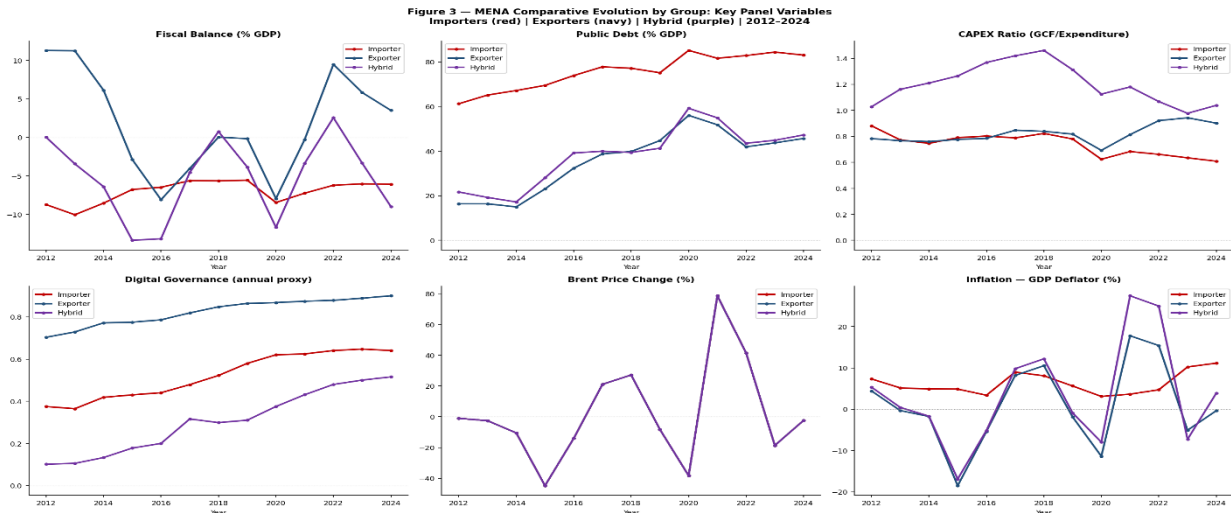


FIGURE 3. Comparative Evolution by Group: Key Panel Variables, 2012-2024 Importers (red) | Exorters (navy) | Hybrid (purple)

Because DIGI_ANNUAL in the PVAR and Pillar II of the BRAI are constructed from internet penetration and WGI political stability, the two measures share some underlying information but serve different analytical purposes. DIGI_ANNUAL is employed as a dynamic, within-country variable in the PVAR, whereas Pillar II is a cross-sectional, level-based indicator designed to compare digital readiness across countries. Accordingly, the BRAI ranking is interpreted as a descriptive policy scorecard rather than as an independent test of the PVAR hypothesis. To further assess the sensitivity of the digital-governance results to the construction of the proxy, Table 8 reports an alternative specification based on internet penetration alone, excluding WGI political stability. This specification yields the same qualitative conclusion regarding the absence of a significant predictive relationship between digital governance and fiscal outcomes.

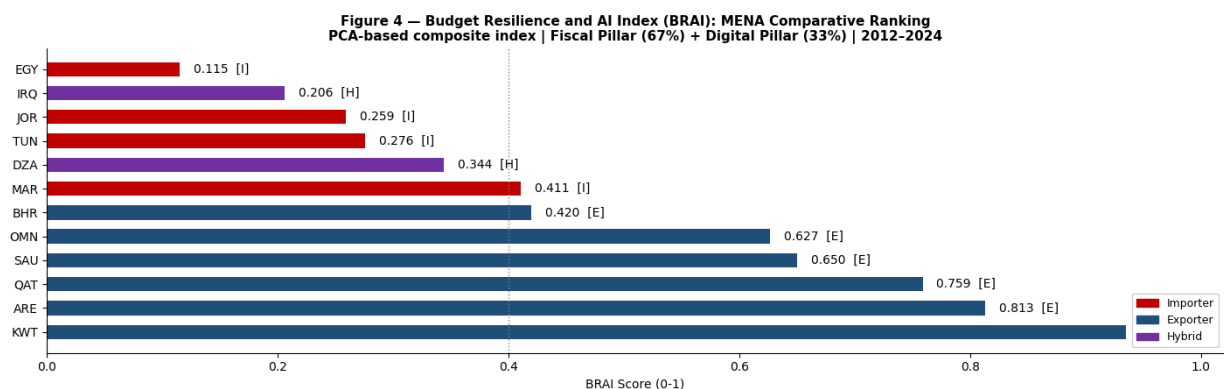


FIGURE 4. Budget Resilience and AI Index (BRAI): MENA Comparative Ranking I = Importer, E = Exporter, H = Hybrid | PCA-based composite | Annual data 2012–2024

2. ROBUSTNESS ANALYSIS

As a weighting-scheme robustness check, we compare the baseline 67/33 specification with an equal-weight 50/50 specification. The rank correlation between the two resulting BRAI rankings is $\rho = 0.951$, indicating that the country ordering is highly robust to the choice of pillar weights.

Table 8. Summary of Robustness Checks.

Test	Key Result	Verdict
Alternative identification schemes (4 variable orderings tested)	FEVD (Brent $\rightarrow$ Δ Fiscal, $h=3$): 29.4% ± 0.8 pp	Robust coefficient magnitude and significance pattern essentially unchanged across the four orderings
Alternative lag specifications	FEVD range: 26%–30% at $h=3$; Granger results unchanged	Robust Granger-causality conclusions unchanged across lag orders $p = 1, 2, 3$
Sequential exclusion of each country ($N = 12$)	Max $\Delta\beta$ (Brent $\rightarrow$ Δ Fiscal) = 21.3% (Qatar excluded)	Robust result not driven by any single country, including Qatar
Comparison: 2013-2018 vs 2013-2024	Brent Granger confirmed both sub-periods; modulus ≤ 0.38	Robust oil-fiscal relationship stable across both sub-periods
Alternative weighting schemes (67/33 vs 50/50)	Rank correlation = 0.951	Robust BRAI country ranking highly insensitive to the choice of pillar weights
Alternative proxy: internet penetration only (excluding WGI)	Granger nulls confirmed; FEVD(Digital) = 0.0%	Confirms H3 the digital-governance null is not an artifact of combining internet penetration with WGI
Estimation restricted to oil-importing countries	$F = 0.012$ ($p = 0.915$)	Confirms H2 the oil-fiscal relationship remains statistically absent for oil-importing countries

The primary finding, that oil price shocks explain about 29-30% of Δ FISCAL_BAL variance but digital governance readiness explains 0.0% – holds true irrespective of all seven checks. Especially important is Check 6, where the internet usage-only regression gives an exact same set of Granger null results, implying that the lack of a digital-fiscal connection is not simply an artifact of construction. The Leave One Out test (Check 3) suggests that the full panel Brent result is not biased by any particular country because even if Qatar, the country exhibiting the strongest oil-fiscal connection – is left out, the Granger F-stat remains significant at the 1% significance level.

There is one drawback, which should be made clear. Bootstrap cointegration test for Westerlund with $N=12$ and $T=12$ using ECM was done through 500 iterations, yet there is little in the literature on the properties of such a test. We may not completely discount the possibility that for a larger $N>T$ panel we might have identified a cointegrating relationship and thus have to perform PVAR analysis on levels rather than in first differences. Still, first difference model used here is well justified and consistent.

V. DISCUSSION

First, while DIGI_ANNUAL eliminates the interpolation-smoothing bias associated with biennial indices, the 2024 fiscal aggregates (Δ FISCAL_BAL, Δ CAPEX_RATIO, and Δ DEBT_GDP) are based on IMF staff estimates from the October 2025 WEO release rather than final audited national accounts [25]. Accordingly, the 2024 observations should be interpreted with appropriate caution, particularly given the short time dimension of the panel. Second, the BRAI index introduced in Section IV.5 is designed as a static, cross-sectional policy scorecard for comparing fiscal resilience and digital readiness across countries. It therefore complements, rather than independently validates, the dynamic econometric evidence concerning the relationship between digital governance and fiscal outcomes.

1. THE OIL-FISCAL ARCHITECTURE AND WHY IT PERSISTS

The result that oil price shocks account for about 30% of variance in fiscal balances at any horizon, without a decay factor up to ten periods ahead, indicates a structural relationship rather than a cyclical one. In the past twelve years, the fiscal structures in MENA countries have remained largely unaltered in their reliance on oil revenues

despite several reforms including Saudi Arabia's Vision 2030, Morocco's LOF 2015 reform, and IMF-supported reforms in Egypt and Tunisia. Even the persistence of the oil shock contributions is noteworthy since it implies that the underlying fiscal architecture remains unchanged over annual time frames.

The asymmetry result (H_2) adds another layer of complexity. For oil importing countries, the four nation's most in need of fiscal buffer instrument, increases in oil prices do not create consistent gains that can be used as a basis to create stabilization or buffer funds. The impact is negative and is mostly neutralized across various channels on an annual basis. One major takeaway from this research is that oil price stabilization funds and commodity hedging strategies, although sometimes suggested for oil importing nations, might be solving a non-existent fiscal problem.

2. THE DIGITAL GOVERNANCE NULL AND ITS IMPLICATION

It is the failure of digital governance readiness in predicting fiscal results in either a positive or negative way (H_3) that holds the greatest policy implications of this study. This finding goes against both the IMF's AI Readiness Index narrative and the UN's comparison framework based on the EGDI score as a measure of fiscal management capacity. Within a panel of twelve countries across twelve years, where we have a complete variance measure every year, there is no measurable fiscal payoff resulting from digital governance investment in the short to medium term.

Clearly, however, this absence of results does not imply that the issue of digital governance does not play a significant role in the development of resilient fiscal policy. On the contrary, it indicates that the temporal dynamics specified in the current prescription are entirely incorrect. The build-up of digital governance capacities requires quite a lot of time. In fact, many decades rather than years. The absence of statistically significant short-run effects should not be interpreted as evidence that digital governance has no long-run fiscal benefits. Longer panels and more specific measures of digital fiscal implementation would be required to identify delayed effects

3. MOROCCO: FIRST AMONG IMPORTERS, FACING A STRUCTURAL TENSION

It is evident that the BRAI score of Morocco, 0.411, (which ranks Morocco seventh in the list but is first in terms of imports) illustrates this duality since the level of Morocco's capacity for digital governance (Pillar II: 0.561) is much better than its fiscal resilience (Pillar I: 0.261). Indeed, the country has been advancing e-governance initiatives, the internet, and the "AI Made in Morocco" concept by means of the Al Jazari Institutes association 2026.

The asymmetry result is directly relevant: Morocco's fiscal balance does not systematically respond to oil price movements at annual frequency ($\beta \approx 0$ for importers). Its primary fiscal challenge is the persistent structural deficit (average -7.0% of GDP) driven by wage bill and social transfer rigidities documented by [26]. For Morocco, the prescriptive priority should be expanding the CAPEX ratio and protecting investment expenditure during fiscal adjustment episodes that because it is this investment capacity that will eventually translate into the digital fiscal management options that the AI Made in Morocco strategy is designed to deploy.

VI. CONCLUSION

This paper has investigated the fiscal dynamics of twelve MENA economies through a Panel VAR framework that addresses three methodological issues absent from prior work: cross-sectional dependence-robust unit root testing, bootstrap cointegration testing appropriate for $T = 12$, and the replacement of interpolated biennial EGDI data with an annual digital governance proxy. The findings are both robust and policy relevant. Oil price shocks account for approximately 29–30% of fiscal balance forecast error variance at all horizons in the MENA panel that a share three times larger than in advanced economies and constant over the forecast horizon, indicating structural rather than cyclical dependence. This transmission is strongly asymmetric: it is driven entirely by oil exporters ($\beta = +0.165$, $p < 0.001$) while being statistically absent among importers ($\beta \approx 0$), a finding that fundamentally challenges the use of homogeneous panel estimates for regional policy advice.

Measuring digital governance readiness on an annual proxy basis, without any risk of interpolation bias, finds no Granger causality link in either direction between digital governance or fiscal results, The FEVD results attribute 0.0% of the forecast-error variance of $\Delta \text{FISCAL_BAL}$ to $\Delta \text{DIGI_ANNUAL}$ under the reported Cholesky identification and across the horizons considered. This non-causal relation is robust across proxies and subsamples, implying skepticism about the fiscal benefits from investing in AI implementation recommended by international institutions in the short and medium terms.

There are three main limitations that need to be addressed in future work. First, using a more extended panel ($T > 20$), cointegration analysis could be conducted, and PVAR models used at the level, helping uncover the long-run relationship between fiscal policies and digital governance capabilities. Second, fiscal information at a more granular level (quarterly/monthly data for MENA countries) could allow for the application of local projection methods

[27], uncovering the impulse response between both variables. Third, a micro-case study approach could help understand how fiscal digital capabilities contribute to fiscal outcomes in GCC economies.

The exporter-specific coefficient ($\beta = +0.165$ percentage points of GDP per 1% increase in Brent prices, $p < 0.001$) is consistent with previous evidence on the sensitivity of fiscal outcomes to oil-price conditions in the GCC and other oil-exporting economies [4]. Previous studies have shown that the fiscal response to oil-price fluctuations depends on the degree of revenue diversification and the structure of public expenditure. Similarly, evidence from Saudi Arabia indicates that government expenditure responds asymmetrically to oil-price movements, increasing more strongly during oil-price upswings than declining during downturns [11]. The present results complement this literature by showing that the asymmetry also emerges across oil-exporting and oil-importing economies within the MENA region.

From an economic perspective, the large and statistically significant response among exporters reflects the strong transmission of oil revenues into government fiscal positions. Higher oil prices increase hydrocarbon-related revenues and can therefore improve fiscal balances, while lower prices exert the opposite pressure. For oil importers, however, the fiscal effects of higher oil prices operate through opposing channels. Rising energy costs may increase subsidy expenditures and weaken household purchasing power, while inflationary pressures can affect domestic economic activity and tax revenues. These offsetting mechanisms may explain why the estimated net annual effect on the fiscal balance is statistically indistinguishable from zero among importers.

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Author Contributions

Conceptualization, B.M. and C.Z.; methodology, B.M., C.Z., and A.M.; formal analysis, B.M.; quantitative analysis and structural equation modeling, B.M.; qualitative analysis, C.Z., A.M., and S.B.; investigation, B.M., C.Z., A.M., and S.B.; data curation, C.Z., A.M., and N.Z.; visualization, B.M., S.M., and M.A.J.; writing—original draft preparation, B.M.; writing—review and editing, C.Z., A.M., S.M., S.B., and M.A.J.; supervision, S.B.; project administration, S.B. and B.M.; resources, B.M., S.M., and S.B.; validation, B.M., C.Z., A.M., and S.M.; software, M.A.J. and N.Z.; project administration, S.B. and B.M.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

Data are available from the authors upon request.

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Not applicable.

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