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Oil Revenue Shocks and Fiscal Performance in Libya

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صدمات الإيرادات النفطية والأداء المالي في ليبيا

فتحي جمعة الورفلي *
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Abstract
This paper examines how oil-price and oil-production shocks are associated with Libya's fiscal balance during 2010–2023. A parsimonious dynamic specification, estimated with HC3 heteroskedasticity-consistent inference, distinguishes changes in world oil prices from domestic production disruptions. Both shocks have positive, statistically significant contemporaneous coefficients, and the fiscal balance exhibits substantial persistence. The production coefficient remains relatively stable when potentially influential years are excluded individually. By contrast, the implied long-run multipliers are imprecisely estimated, with confidence intervals that include zero. Residual and specification diagnostics do not reject their respective null hypotheses, while recursive cumulative-sum evidence detects no parameter instability; these tests have limited power in a short annual sample. The findings suggest that fiscal planning in Libya needs to account separately for international price volatility and interruptions to domestic oil output.

Keywords: Libya; oil-price shocks; oil-production shocks; fiscal balance; fiscal persistence.

الملخص
تبحث هذه الدراسة في كيفية ارتباط صدمات أسعار النفط وصدمات إنتاجه بالأداء المالي في ليبيا خلال الفترة 2010–2023. وبدلاً من تمثيل التعرض النفطي بمؤشر واحد للإيرادات أو بصدمة مركبة، تفصل الدراسة بين المكوّن السعري الدولي والتغيرات في الإنتاج المحلي، وهو تمييز مهم في اقتصاد يمكن فيه لانقطاعات الإنتاج أن تغيّر الموارد العامة بصورة حادة حتى عندما تكون الأسعار العالمية مواتية. وباستخدام بيانات سنوية ومواصفة ديناميكية مقتصدة مع استدلال متين لتباين الأخطاء من نوع HC3، تُظهر النتائج درجة مرتفعة من الاستمرارية المالية وارتباطات موجبة ومعنوية إحصائياً في الأجل القصير لكل من صدمة السعر وصدمة الإنتاج. ويظل أثر الإنتاج مستقراً بوجه خاص عند استبعاد سنوات يحتمل أن تكون مؤثرة. وتشير ديناميكيات النموذج إلى تكيف مالي تدريجي، بينما تبقى المضاعفات طويلة الأجل موجبة ولكن غير مقدرة بدقة. ولا تكشف اختبارات البواقي والمواصفة وCUSUM عن فشل واضح، مع الإقرار بأن قصر العينة يحد من قوة هذه الاختبارات. وتدل النتائج على أن الهشاشة المالية الليبية تعكس خطرين نفطيين متميزين: خطر السعر الخارجي وخطر الإنتاج المحلي..

الكلمات المفتاحية :ليبيا؛ صدمات أسعار النفط؛ صدمات إنتاج النفط؛ الميزان المالي؛ الاستمرارية المالية.

1. Introduction

For oil-exporting economies, fiscal exposure extends beyond fluctuations in the world price of crude oil. The budgetary consequences of a price movement depend on the volume produced and sold, the conversion of export proceeds into government receipts, and the expenditure response. Governments may save part of a windfall, expand spending, draw down assets, or defer adjustment when revenues contract. The fiscal balance reflects these decisions jointly; it is not simply a restatement of oil-price movements (El Anshasy & Bradley, 2012; Alley, 2016). Libya illustrates why price and quantity disturbances should be distinguished. Hydrocarbon receipts have long financed a substantial share of public expenditure, but the oil sector has also experienced repeated production interruptions. Changes in world prices are largely external to domestic fiscal decisions, whereas variations in physical output may reflect shutdowns, conflict, operational constraints, or subsequent recovery. A favorable international price cannot generate the same fiscal resources when production is interrupted (Masoud, 2013; Etelawi et al., 2017).

This feature is easy to lose when oil dependence is represented by a single price variable or by government hydrocarbon revenue itself. The first approach can understate domestic quantity risk. The second mixes the original disturbance with a fiscal outcome that is already shaped by price, production, the exchange rate, and institutional or accounting arrangements. For the present study, the distinction is consequential: price and production are treated

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as the primary sources of oil-sector disturbance, realized hydrocarbon revenue provides the economic transmission mechanism used in interpretation, and the overall fiscal balance is the principal measure of fiscal performance.

Earlier work on Libya documents the importance of hydrocarbon revenue and the transmission of oil disturbances to output, prices, and other macroeconomic variables (Ali & Harvie, 2014; Aimer, 2016; Etelawi et al., 2017). Studies of other oil exporters also suggest that public spending does not necessarily adjust contemporaneously or symmetrically to revenue changes (Farzanegan, 2011; Hamdi & Sbia, 2013). These findings motivate an examination of the fiscal balance itself, with separate measures of international price and domestic production shocks.

The paper addresses this narrower problem using annual data for 2010–2023. The sample is short, and that fact shapes the design from the outset. The preferred model is deliberately parsimonious: the fiscal balance as a percentage of GDP depends on its own lag and on separate oil-price and oil-production shocks. The lag permits gradual fiscal adjustment; the two shock variables preserve the distinction between external market conditions and domestic quantity disturbances. More elaborate specifications are treated as extensions or robustness exercises rather than as a reason to exhaust the limited degrees of freedom.

The estimated coefficients are positive and statistically significant for both shocks in the preferred specification, even after conditioning on the lagged fiscal balance. The latter coefficient indicates marked persistence. Inference is less decisive for the nonlinear long-run multipliers: their point estimates are positive, but the reported confidence intervals include zero. The distinction between contemporaneous association and long-run precision is central to the interpretation.

Hydrocarbon government revenue provides the natural economic channel through which price and production conditions can reach the budget. The paper uses that channel to organize interpretation rather than presenting it as a separately identified mediation model. This distinction is important because realized hydrocarbon receipts combine price, production, exchange-rate, export-realization, and institutional influences, while government revenue also enters the fiscal balance by construction. The empirical contribution therefore remains centered on the direct dynamic relationship between separate oil shocks and fiscal performance.

The contribution is consequently focused. First, the study separates international price risk from domestic production risk in explaining Libya's fiscal performance. Second, it places fiscal persistence alongside the contemporaneous oil effects, so the adjustment process is part of the empirical story rather than an afterthought. Third, it interprets the estimated responses through Libya's hydrocarbon-revenue mechanism while keeping the accounting identity visible and avoiding an unsupported claim of causal mediation. The aim is not to produce a highly parameterized model from a very small sample, but to extract a defensible and economically coherent account of Libya's oil–fiscal exposure from the data that can be supported.

The paper therefore asks a deliberately focused question: how do oil-price and oil-production shocks separately relate to Libya’s fiscal balance, and how persistent is the resulting fiscal adjustment? The contribution is not to construct a larger forecasting system, but to isolate two economically different sources of oil exposure within a parsimonious dynamic framework suited to the available annual sample. The remainder of the paper reviews the relevant oil–fiscal literature and the Libyan evidence, develops the conceptual distinction between price and production risk, explains the data and empirical strategy, reports the baseline and robustness results, and discusses their fiscal implications.

2. Literature Review and Research Gap

2.1 Oil shocks and fiscal adjustment in oil-exporting economies

Oil-exporting economies are particularly exposed to oil-market disturbances because hydrocarbon receipts often constitute a substantial share of government revenue. The first-order effect is familiar: an oil-price or oil-output movement changes the revenue environment. The fiscal consequence is less mechanical. Once receipts change, governments decide whether to alter expenditure, accumulate or draw down financial assets, borrow, or allow the fiscal balance to absorb part of the shock. Fiscal policy is therefore not merely a passive endpoint. It is one of the channels through which oil-sector volatility is propagated into the domestic economy.

A central strand of the literature examines the response of public expenditure to oil-revenue shocks. Farzanegan (2011), using evidence from Iran, shows that expenditure categories need not react uniformly to an oil-revenue disturbance. This matters because the fiscal cost of a negative shock depends partly on which commitments can be adjusted and how quickly. Hamdi and Sbia (2013) reach a related conclusion in an oil-dependent setting: oil revenues remain a principal source of government financing, while current expenditure can remain comparatively rigid and capital or development expenditure responds more strongly to revenue fluctuations. A fall in oil receipts therefore need not be matched by an immediate fall in total spending. The first visible consequence may instead be a deterioration in the fiscal balance.

Cross-country evidence reinforces the same point from a different angle. El Anshasy and Bradley (2012) estimate fiscal-policy reaction functions for oil exporters and show that fiscal responses vary across horizons and with the nature of oil-price movements. Their results caution against a one-to-one contemporaneous mapping from additional oil income to public spending. Institutional arrangements, financing constraints, and the capacity to save

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windfalls or smooth expenditure can alter the timing and magnitude of adjustment. Similar oil shocks can therefore produce different fiscal outcomes across countries without contradicting the underlying importance of oil revenue. This literature also explains why expenditure alone is an incomplete measure of fiscal performance. Alley (2016) uses a fiscal-balance measure to capture the joint outcome of government revenue and expenditure decisions. The distinction is substantive. A government can face a large revenue shock while maintaining expenditure temporarily, allowing the balance to deteriorate; alternatively, expenditure compression or the use of buffers can change the path of adjustment. The fiscal balance is thus useful precisely because it records the net result after both sides of the budget have responded.

Taken together, these studies suggest that fiscal responses to oil shocks depend on both the revenue impulse and the adjustment of spending. Recent evidence strengthens this interpretation. Agboola, Chowdhury, and Yang (2024) study oil-exporting emerging economies and document asymmetric responses of output and government expenditure to oil-price innovations. Their analysis cautions against assuming that positive and negative oil shocks generate mirror-image fiscal adjustments. The present study does not test asymmetry: with only thirteen usable annual observations in the dynamic specification, it instead isolates price and production movements in a linear model. This difference in scope is substantive rather than a contradiction of their findings.

2.2 Libya: oil dependence, production disruptions, and the fiscal channel

Libya is not simply another oil exporter with a high hydrocarbon share. Oil income has historically occupied a dominant position in public revenue, and the state captures much of the fiscal gain generated by the sector. Ali and Harvie (2014) provide a useful theoretical account of this structure. In their treatment of oil-related shocks, higher oil production and income first generate a revenue effect and are then transmitted through a spending effect as government consumption and development expenditure respond to the resources available. The fiscal system is therefore central to the recycling of oil income through the Libyan economy.

That mechanism is supported by broader structural accounts. Masoud (2013) documents the role of oil and natural-gas revenue in financing public and development expenditure and supplying foreign exchange, while also noting the budgetary consequences of earlier oil-price declines. Etelawi, Blatner, and McCluskey (2017) similarly emphasize the exceptional weight of hydrocarbons in public revenue and export receipts. These studies do not by themselves identify the dynamic response of the fiscal balance, but they establish why an oil disturbance should have an immediate fiscal dimension in Libya.

Other empirical work concentrates more directly on macroeconomic transmission. Chouikhi, Jbir, and Boujelbene examine real oil-price movements within a VAR framework that includes economic activity, inflation, and the real exchange rate. Their analysis demonstrates that oil-price shocks have measurable dynamic effects in the Libyan economy, while fiscal performance is not the principal modeled outcome. Aimer (2016) likewise studies oil-price fluctuations and economic growth, emphasizing the country's dependence on oil income and the difficulties that volatility creates for government revenue and fiscal management. The fiscal channel is present, but it is not the central dependent relationship.

Production adds a complication that is especially important after 2010. Libya has experienced large changes in realized oil output associated with shutdowns, conflict, institutional fragmentation, and interruptions to export infrastructure. Ben-Taher (2024), using quarterly observations for 2012 Q4–2022 Q3, applies multiple-break tests and a structural vector autoregression to investigate how oil-sector revenue disturbances affect Libyan macroeconomic variables. His findings connect oil-sector crises with exchange-rate and monetary instability and highlight the importance of political and security conditions. That study does not estimate the separate association of international oil-price changes and domestic production changes with the overall fiscal balance. The present paper addresses precisely that narrower fiscal outcome, without claiming the structural identification achieved by a structural VAR.

This distinction also clarifies why realized hydrocarbon revenue should not be used uncritically as the primitive shock. Government receipts already embody the interaction of price, quantity, exchange-rate conditions, export realization, and institutional or accounting arrangements. Revenue is economically central, but conceptually it sits between the original oil disturbance and the final fiscal outcome. Treating it as the shock itself would blur the mechanism the paper is trying to examine.

2.3 Research gap and contribution

The research gap is therefore specific. Work on oil exporters establishes the importance of fiscal adjustment to oil disturbances, and recent cross-country evidence identifies potentially asymmetric expenditure responses (Agboola et al., 2024). Libya-specific evidence establishes that oil-sector crises have broad macroeconomic consequences (Ben-Taher, 2024), but does not isolate the separate contributions of international oil-price movements and domestic production movements to the fiscal balance in the same compact dynamic equation. We address that question for 2010–2023 while treating the short sample and the absence of structural shock identification as explicit limitations.

The primary contribution is therefore to estimate the fiscal effects of international price movements and domestic production movements within the same parsimonious dynamic specification. The paper asks whether both

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dimensions of oil-sector volatility matter for fiscal performance and whether the production channel retains explanatory power once price movements are accounted for. A second, supporting contribution is to examine realized hydrocarbon government revenue as evidence on the transmission mechanism. This part of the analysis is intentionally more cautious: it seeks consistency between the main shock results and the revenue channel without presenting the revenue–balance relationship as independent causal identification.

This positioning also changes the emphasis of the study. The paper is not a general investigation of every determinant of Libya's fiscal balance, nor is it an attempt to build a complete structural model of public finance from fourteen annual observations. It focuses on a narrower empirical question that the available data can address with greater credibility: how distinct oil shocks are associated with fiscal performance, how persistent that performance is, and whether realized hydrocarbon revenue behaves in a manner consistent with the proposed fiscal channel.

3. Conceptual Framework and Hypotheses

The conceptual framework separates three levels that can easily be conflated in an oil-dependent fiscal system: the source of the disturbance, the channel through which it reaches government finances, and the fiscal outcome observed after the budget responds. In compact form, the sequence is: oil-price and oil-production shocks → realized hydrocarbon government revenue → fiscal adjustment → fiscal balance. The sequence is an organizing mechanism, not a claim that every arrow is independently identified by the empirical design.

The price channel begins outside the Libyan fiscal accounts. For a given quantity of oil, a positive international price shock raises the gross value of production and, other things equal, expands the base from which hydrocarbon receipts can be generated. A negative shock reduces that value. The eventual effect on the fiscal balance depends on more than the price itself: exchange-rate arrangements, revenue realization, expenditure decisions, and the use of fiscal buffers can all change the magnitude and timing of the response. The price shock is nevertheless conceptually distinct from the fiscal outcome it may produce.

The production channel is different. A change in Libyan output can arise from domestic supply conditions, including shutdowns and interruptions that have little to do with the contemporaneous world price. When production falls, the government can lose revenue-generating capacity even in a favorable external market. When output is restored, fiscal resources can recover without an equally large price increase. Production risk therefore deserves an independent coefficient rather than being hidden inside a composite oil measure.

Realized hydrocarbon revenue links these disturbances to the budget. It is the fiscal resource most directly generated by the oil sector, but it is not exogenous in the same sense as an international price movement. It reflects price and production together with exchange-rate conditions, export realization, and institutional arrangements. The revenue variable is therefore useful for testing whether the data display the intermediate movement implied by the main shock variables. Its relation to the fiscal balance requires a second qualification: because hydrocarbon revenue is part of government revenue, the budget identity creates an accounting connection between the two variables.

The accounting identity does not eliminate economic content. A one-unit increase in hydrocarbon revenue need not improve the fiscal balance by one unit if expenditure, non-hydrocarbon revenue, financing operations, or other fiscal components move at the same time. The estimated association can therefore reveal how the fiscal position co-moves with changes in the resource base. What it cannot do, on its own, is transform that association into a clean causal mediation effect. The empirical strategy preserves this distinction by placing the direct shock–fiscal relationship at the center and using the revenue regressions as supporting channel evidence.

Fiscal persistence completes the framework. If expenditure commitments and other budgetary arrangements adjust gradually, the current fiscal balance can depend materially on the previous year's position. A lagged dependent variable captures this inertia without requiring the model to assign it prematurely to a single institutional cause. The resulting specification is deliberately modest: it asks whether oil shocks matter after allowing for persistence, rather than trying to identify every mechanism through which persistence arises.

H1. Oil-price shocks significantly affect Libya’s fiscal balance.

H2. Oil-production shocks significantly affect Libya’s fiscal balance.

4. Data, Variable Construction, and Empirical Strategy

The core estimation window is 2010–2023, providing fourteen consecutive annual observations. An earlier 2004–2007 block is retained for historical context where useful, but the 2008–2009 gap prevents its automatic incorporation into a continuous dynamic specification. Missing fiscal observations are not interpolated or back-cast merely to enlarge the sample. With such a small T, every additional regressor and lag has a visible cost in degrees of freedom; parsimony is therefore a methodological requirement rather than a stylistic preference.

Fiscal performance is measured by the overall fiscal balance as a percentage of gross domestic product (GDP). The nominal fiscal balance, reported in millions of Libyan dinars (LYD), is divided by nominal GDP in LYD and multiplied by 100. Nominal GDP in LYD is obtained from current-dollar GDP multiplied by the official LYD-

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per-US-dollar exchange rate. The final annual dataset combines fiscal outturns compiled from Central Bank of Libya (CBL) and International Monetary Fund (IMF) reporting, nominal oil prices from the World Bank commodity-price data (Pink Sheet), Libyan oil production from BP/Energy Institute series, and GDP and exchange rates from the World Bank World Development Indicators (WDI). Values were not interpolated to fill missing fiscal years. The 2010 fiscal values are rounded and subject to limited differences in reporting basis across official publications; they are retained with this qualification. The archived data-freeze documentation specifies a mixed fiscal reporting basis: 2011 is drawn from CBL budget-execution figures; 2012–2013 expenditure is reported on a financial-authorizations basis; 2014–2015 fiscal totals are rounded; and 2018–2023 use an IMF historical series. Consequently, the fiscal observations should not be interpreted as a perfectly harmonized audited cash-basis series. The source workbook retains these qualifications at the observation level.

Equations (1) and (2) define the annual price and production shock measures. P_t is the nominal oil price in US dollars per barrel, Q_t is Libyan oil production in thousands of barrels per day, ln is the natural logarithm, and t indexes calendar years. The first observation for each growth-rate shock is 2011. Equation (3) defines the composite oil-value log change, which is used only as a robustness indicator. The source workbook also stores conventional arithmetic percentage changes for convenience; these differ from the log-change shocks defined in Equations (1)–(3) and must not be substituted for them.

The composite measure in Equation (3) is algebraically equal to the percentage log change of the price–quantity product; it is not a structural measure of oil-revenue shocks, which additionally depend on realized sales, fiscal take, exchange rates, and accounting arrangements. The baseline therefore retains separate price and production regressors.

Equation (4) specifies the preferred dynamic fiscal model. $FBGDP_t$ is the overall fiscal balance as a percentage of GDP; α is the intercept, ρ measures fiscal persistence, β_p and βq are contemporaneous coefficients for price and production changes, and ε_t is the regression disturbance. A single lag is retained to conserve degrees of freedom.

(1) $PShock_t = 100 \times [\ln(P_t) - \ln(P_{t-1})]$
where P_t is the annual oil price in US dollars per barrel. $PShock_t$ therefore measures the annual percentage log change in the oil price.

(2) $QShock_t = 100 \times [\ln(Q_t) - \ln(Q_{t-1})]$
where Q_t is Libyan oil production in thousand barrels per day. $QShock_t$ measures the annual percentage log change in physical production.

A composite oil-value shock is retained only as a robustness measure. It is economical in parameters, but it cannot distinguish a favorable international price movement from a recovery in domestic production; that distinction is central to the paper.

(3) $OilShock_t = PShock_t + QShock_t = 100 \times \Delta\ln(P_tQ_t)$
The composite measure is not the baseline specification because equal-sized changes in price and production need not carry the same economic interpretation for Libya.

The preferred fiscal specification is deliberately parsimonious. It allows the current fiscal position to depend on its own recent history while estimating the contemporaneous contributions of price and production shocks separately.

(4) $FBGDP_t = \alpha + \rho FBGDP_{t-1} + \beta_p PShock_t + \beta q QShock_t + \varepsilon_t$
$FBGDP_t$ is the overall fiscal balance as a percentage of GDP; ρ captures fiscal persistence; β_p and βq measure the contemporaneous fiscal associations of the price and production shocks; ε_t is the disturbance term.

Hydrocarbon revenue is retained as an interpretive transmission mechanism rather than estimated as a third headline equation. Price and production conditions affect the value of the oil resource base from which government receipts are realized, but hydrocarbon revenue is itself shaped by exchange-rate, export-realization, and institutional factors and is also an accounting component of the fiscal balance. For that reason, the reported regressions focus on the direct price-shock and production-shock associations with fiscal performance; the revenue channel is used to interpret, not to over-identify, those relationships.

Inference is deliberately conservative. The preferred estimates are accompanied by HC3 heteroskedasticity-consistent standard errors, influential-year exercises, residual diagnostics, and recursive stability evidence. Conventional unit-root tests are reported but interpreted cautiously because their power is limited in a sample of this size. The baseline is intentionally restricted to the two pre-specified oil shocks and one lag of the fiscal balance so that the empirical claims remain proportionate to the available degrees of freedom. Source: Author's calculations using the study data and reported model outputs.

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4.1 Variables and data sources

Table 1. Core variables, construction, sources, and estimation coverage

Variable / symbol	Definition and unit	Construction / role	Principal source	Coverage
Fiscal balance (FBGDP)	Overall fiscal balance, % of GDP	Main fiscal outcome; nominal balance scaled by GDP in local currency	Central Bank of Libya fiscal actuals; World Bank WDI for GDP and exchange-rate scaling	2010–2023
Oil price (P)	Annual oil price, USD/barrel	External price exposure	World Bank Pink Sheet	2010–2023
Oil-price shock (PShock)	Annual log change in oil price, %	$100 \times \Delta\ln(P)$	Constructed from Pink Sheet price series	2011–2023
Oil production (Q)	Libyan oil production, thousand barrels/day	Physical oil-sector volume	BP / Energy Institute production series	2010–2023
Oil-production shock (QShock)	Annual log change in oil production, %	$100 \times \Delta\ln(Q)$	Constructed from production series	2011–2023
Composite oil shock (OilShock)	Approx. annual log change in price × quantity, %	PShock + QShock; robustness only	Constructed	2011–2023

Note: Fiscal outturns: CBL annual reports and IMF fiscal tables; nominal GDP and official exchange rate: WDI; oil price: World Bank Pink Sheet; production: BP/Energy Institute. Fiscal balance/GDP (%) = 100 × fiscal balance (million LYD) / [GDP (current US$) × official exchange rate (LYD/US$) / 1,000,000]. No fiscal interpolation was used. The 2010 fiscal figures are rounded official candidates and may differ modestly across reporting bases. Original agency publications and the author's final data workbook provide the underlying annual series. Source: Author's calculations from the study dataset and stated institutional sources. Provenance qualification: the archived workbook identifies agencies and fiscal-year decisions but does not provide a verified report-page/table reference for every observation. This is a documented limitation of source-level traceability, not evidence that every annual value has been independently reconciled to the original report.

5. Empirical Results

5.1 Descriptive evidence and time-series properties

Table 2 reports substantial fiscal variation during 2010–2023. The mean fiscal balance is −4.774 percent of GDP, with a standard deviation of 19.383 percentage points; the observed range extends from −37.153 to 23.595 percent. The oil-production shock is considerably more dispersed than the price shock, consistent with the scale of domestic output interruptions. Figure 1 plots the fiscal balance over time, while Figure 2 compares the two oil-shock series. These descriptive patterns motivate, but cannot by themselves establish, the dynamic associations estimated below. The augmented Dickey–Fuller (ADF) and Phillips–Perron (PP) results are summarized in Table 3. Both tests reject the unit-root null for the oil-price, oil-production, and composite shock measures, but not for the fiscal balance. A deterministic trend does not change the latter conclusion. Given the very small sample, these outcomes are treated as specification diagnostics rather than decisive evidence on the underlying stochastic processes. Source: Author's calculations using the study data and reported model outputs.

The failure to reject a unit root in the fiscal-balance series is nevertheless a material limitation rather than a result to be ignored. In a sample this short, non-rejection is not decisive evidence that the balance is truly I(1), but it does mean that the level specification should be read as a compact dynamic association rather than as a fully established long-run equilibrium model. This issue is carried into the interpretation of the long-run multipliers and is one reason the paper places its strongest weight on the contemporaneous shock coefficients and robustness checks. Source: Author's calculations.

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Table 2. Descriptive statistics

Variable	Obs.	Mean	Std. Dev.	Minimum	Maximum
Fiscal balance (% of GDP)	14	-4.774	19.383	-37.153	23.595
Oil price shock (%)	13	0.173	31.785	-63.853	51.469
Oil production shock (%)	13	-2.612	72.600	-122.139	108.464
Composite oil shock (%)	13	-2.438	89.165	-143.450	159.933

Note: Oil price and production shocks are annual logarithmic changes. Shock variables contain 13 observations because first differencing removes 2010. The composite oil shock is the sum of the price and production shocks.
Source: Author's calculations.

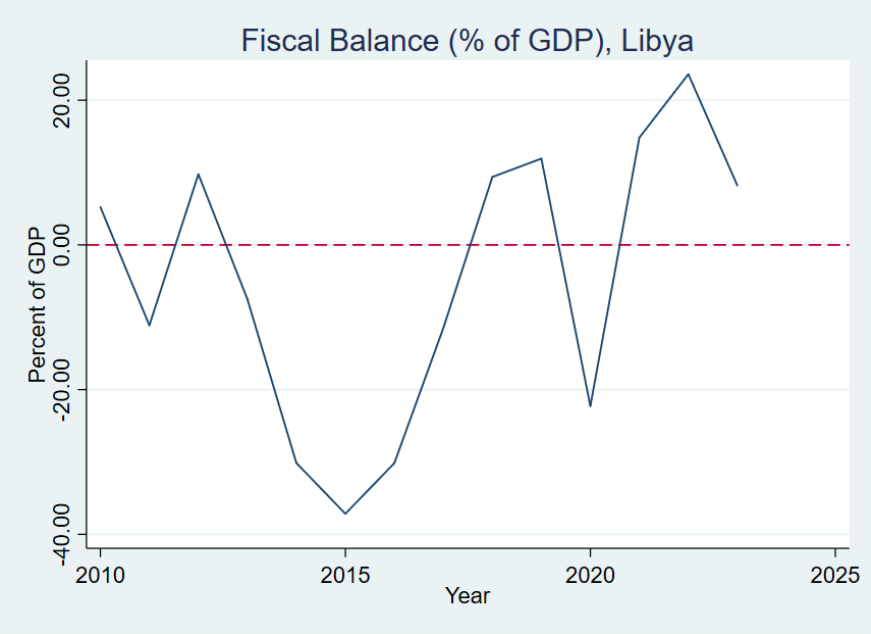


Figure 1. Fiscal balance (% of GDP), Libya, 2010–2023
Source: Author's calculations using the study dataset.

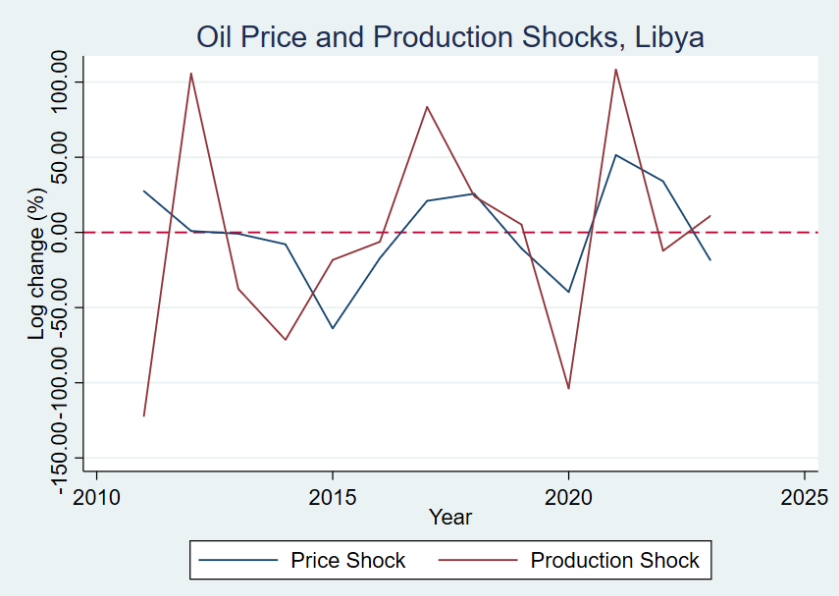


Figure 2. Oil price and production shocks, Libya
Source: Author's calculations using the study data and reported model outputs.

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Table 3. Unit-root and stationarity tests

Variable	ADF stat.	ADF p-value	PP stat.	PP p-value	Inference
Fiscal balance	-2.027	0.2748	-2.038	0.2703	Unit-root null not rejected
Oil price shock	-2.937	0.0412	-2.904	0.0449	Stationary at 5%
Oil production shock	-5.587	<0.001	-5.878	<0.001	Stationary at 1%
Composite oil shock	-4.076	0.0011	-4.205	0.0006	Stationary at 1%

Note: ADF denotes Augmented Dickey–Fuller and PP denotes Phillips–Perron. Tests are in levels without a deterministic trend. Trend specifications for the fiscal balance also fail to reject the unit-root null (ADF p = 0.3763; PP p = 0.4103). Given the very small annual sample, these tests are treated primarily as specification diagnostics. Source: Author's calculations from the study dataset and stated institutional sources.

5.2 Preferred dynamic fiscal model

The preferred estimates appear in Table 4. The lagged fiscal-balance coefficient is 0.7187 (p = 0.001), consistent with substantial persistence. Conditional on that lag and on the other oil shock, the price-shock coefficient is 0.2559 (p = 0.008), whereas the production-shock coefficient is 0.1786 (p < 0.001). Both coefficients are positive and statistically distinguishable from zero under the reported HC3 inference. Source: Author's calculations using the study data and reported model outputs.

The joint interpretation matters more than any coefficient in isolation. The price result confirms that Libya's fiscal position is exposed to international oil-market conditions. The production result shows that this is not the whole story. Changes in realized domestic output retain a separate association with the fiscal balance after price movements are included. A fiscal analysis based only on the international price would therefore omit a source of vulnerability that is economically central in the Libyan setting.

Table 4. Preferred dynamic model estimates

Variable	Coefficient	HC3 Std. Error	t-statistic	p-value
Lagged fiscal balance	0.7187	0.1373	5.24	0.001
Oil price shock	0.2559	0.0763	3.36	0.008
Oil production shock	0.1786	0.0271	6.60	<0.001
Constant	-0.9728	2.3501	-0.41	0.689

Note: Dependent variable: fiscal balance as a percentage of GDP. HC3 heteroskedasticity-consistent standard errors are reported. N = 13; R^2 = 0.9062; F(3,9) = 25.88; Prob > F = 0.0001. Source: Author's calculations from the study dataset and stated institutional sources.

5.3 Adjustment dynamics and longer-run implications

Table 5 translates the preferred coefficients into adjustment measures and implied long-run multipliers. With an estimated persistence coefficient of 0.7187, the implied annual adjustment fraction is 0.2813. The estimated half-life is approximately 2.10 years, although its delta-method uncertainty is substantial (p = 0.084). These transformations describe the fitted dynamic model; they do not independently establish a stable structural long-run equilibrium. Source: Author's calculations using the study data and reported model outputs.

The implied long-run effect of the price shock is approximately 0.9097 and that of the production shock approximately 0.6347. Both are positive, yet their p-values are 0.080 and 0.084 and their 95 percent confidence intervals include zero. The evidence is thus asymmetric in strength across horizons: the contemporaneous response is clear, whereas the exact cumulative long-run magnitude remains uncertain. This is not a contradiction. It is a limit on how far the short-run result can be projected.

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Table 5. Economic effects and fiscal adjustment dynamics

Effect	Estimate	Std. Error	p-value	95% CI Lower	95% CI Upper
Short-run oil price effect	0.2559	0.0763	0.008	0.0833	0.4285
Short-run oil production effect	0.1786	0.0271	<0.001	0.1173	0.2399
Fiscal persistence	0.7187	0.1373	0.001	0.4081	1.0293
Long-run oil price effect	0.9097	0.5201	0.080	-0.1098	1.9291
Long-run oil production effect	0.6347	0.3672	0.084	-0.0849	1.3544
Annual adjustment fraction	0.2813	0.1373	0.040	0.0123	0.5504
Half-life (years)	2.0981	1.2128	0.084	-0.2791	4.4752

Note: Direct coefficients (short-run price, short-run production, and fiscal persistence) use the HC3 t-based inference reported in the preferred regression with 9 residual degrees of freedom. Long-run effects are $\beta/(1-\rho)$; annual adjustment is $1-\rho$; half-life is $\ln(0.5)/\ln(\rho)$. Standard errors, p-values, and confidence intervals for these nonlinear transformations use the delta method and its large-sample normal approximation. The transformed long-run quantities are interpreted cautiously given the small sample. Source: Author's calculations from the study dataset and stated institutional sources.

5.4 Robustness, diagnostics, and stability

Table 6 reports estimates obtained after excluding 2015, 2017, and 2023 separately. The lagged fiscal-balance coefficient remains positive, ranging from 0.6673 to 0.7989. Price-shock coefficients range from 0.2284 to 0.3124, while production-shock coefficients range from 0.1786 to 0.1942. The signs are unchanged, although removing individual observations cannot eliminate the inferential limitations of a sample this small.

Diagnostic results are presented in Table 7. The Breusch–Pagan/Cook–Weisberg test ($p = 0.8318$) does not reject homoskedasticity; the Breusch–Godfrey Lagrange multiplier test ($p = 0.6017$) does not reject the absence of first-order serial correlation. The skewness–kurtosis test ($p = 0.3775$) does not reject residual normality, and the Ramsey regression specification error test (RESET; $p = 0.2000$) does not reject its specification null. Failure to reject these hypotheses is not proof that the assumptions hold, especially with few observations. Source: Author's calculations using the study data and reported model outputs.

The recursive cumulative-sum (CUSUM) statistic is 0.4220, below the reported 5% critical value of 0.9479. Figure 3 shows that the recursive path stays within the corresponding confidence bands. This is evidence of no detected instability under the test employed, not confirmation that Libya's fiscal institutions remained unchanged during the period.

Table 6. Robustness checks: excluding influential years

Source: Author's calculations using the study data and reported model outputs.

Variable	Baseline HC3	Excl. 2015	Excl. 2017	Excl. 2023
Lagged fiscal balance	0.7187	0.7728	0.6673	0.7989
HC3 Std. Error	(0.1373)	(0.2135)	(0.1184)	(0.1612)
Oil price shock	0.2559	0.3124	0.2709	0.2284
HC3 Std. Error	(0.0763)	(0.0886)	(0.0722)	(0.0767)
Oil production shock	0.1786	0.1786	0.1870	0.1942
HC3 Std. Error	(0.0271)	(0.0285)	(0.0282)	(0.0315)
Observations	13	12	12	12
R-squared	0.9062	0.8936	0.9291	0.9116

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Note: HC3 standard errors are reported in parentheses. Each specification excludes one potentially influential year while retaining the same dynamic structure. The exercise is used to assess coefficient stability rather than to re-select the model. Source: Author's calculations.

Table 7. Diagnostic and stability tests

Test	Test statistic	p-value / critical value	Inference
Breusch–Pagan / Cook–Weisberg	$\chi^2(1) = 0.05$	0.8318	No evidence of heteroskedasticity
Breusch–Godfrey LM (lag 1)	$\chi^2(1) = 0.272$	0.6017	No evidence of serial correlation
Skewness/Kurtosis normality	$\chi^2(2) = 1.95$	0.3775	Normality not rejected
Ramsey RESET	$F(3,6) = 2.11$	0.2000	No evidence of functional-form misspecification
CUSUM	0.4220	5% critical value = 0.9479	No instability detected by the test

Note: Diagnostics refer to the preferred dynamic specification. Main regression inference uses HC3 standard errors. The recursive CUSUM remains within the 95% confidence bands; given the short sample, this is evidence of no detected instability rather than proof of structural invariance. Source: Author's calculations from the study dataset and stated institutional sources.

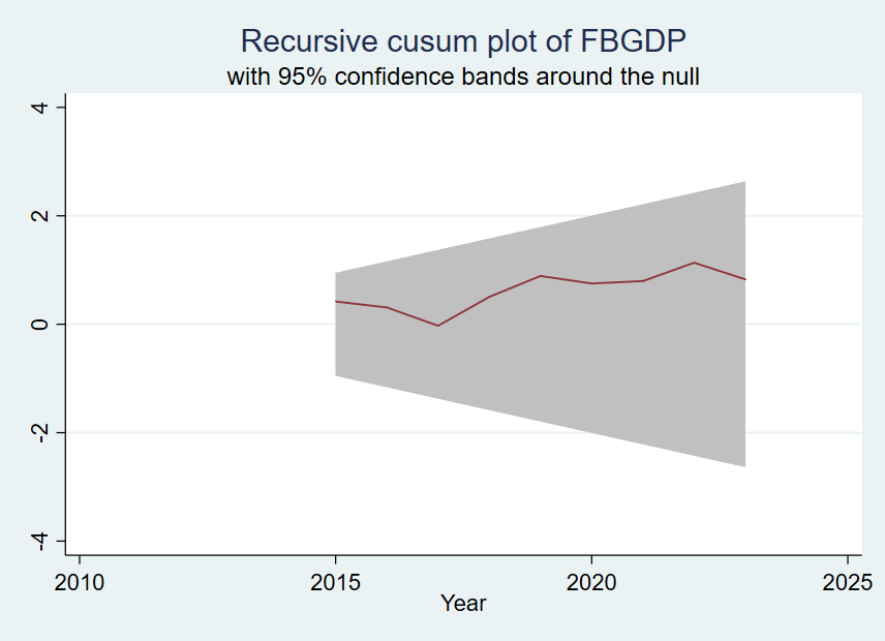


Figure 3. Recursive CUSUM stability plot for the preferred fiscal model

Source: Author's calculations using the study dataset.

5.5 Interpretive hydrocarbon-revenue transmission mechanism

Hydrocarbon revenue remains economically important to the paper's interpretation, but it is not estimated here as a third co-equal causal model. The empirical tables establish the paper's central result directly: separate price and production shocks are positively associated with Libya's fiscal balance, while the production coefficient remains especially stable in the influential-year checks. Revenue is therefore treated as the principal transmission mechanism through which oil-market and production conditions can reach the budget, rather than as an additional hypothesis requiring a separate headline table.

This distinction is deliberate. Realized hydrocarbon receipts are closely connected to the value of oil sold and are also a component of government revenue, so a strong empirical association between hydrocarbon revenue and the fiscal balance would partly reflect economic and accounting structure. Keeping the channel in a supporting role preserves the paper's identification boundary: the reported regressions test the fiscal response to price and production shocks; the revenue mechanism helps interpret those responses without being presented as independently identified mediation.

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Taken together, the preferred model and the robustness checks support both stated hypotheses at conventional significance levels in the short run. H1 is supported by the positive oil-price-shock coefficient, while H2 receives particularly strong support from the positive and highly stable production-shock coefficient. The evidence should not be extended mechanically to the long run: the implied long-run multipliers are positive, but their confidence intervals include zero. The empirical conclusion is therefore strongest for the short-run fiscal response and for the persistence of fiscal conditions.

6. Discussion

The results sharpen the meaning of oil dependence in Libya. Fiscal vulnerability is not adequately described as exposure to the international price alone. The price coefficient is positive and significant, while production changes carry a separate and robust association with the fiscal balance. The distinction is economically meaningful because international price conditions and domestic production continuity are governed by different processes. The estimates should be interpreted as dynamic associations rather than as a fully identified structural causal model, but they show that collapsing the two dimensions into a single oil indicator would conceal information relevant to Libya's fiscal exposure.

The positive price coefficient is consistent with the fiscal exposure of oil-exporting economies. Agboola et al. (2024) provide a useful qualification: government spending responses to oil-price innovations can be asymmetric and vary across countries. Our linear annual specification cannot test that proposition, and its coefficient should not be read as evidence that positive and negative price movements have identical fiscal consequences.

The production result gives the paper a distinctly Libyan interpretation. Its positive coefficient remains comparatively stable when potentially influential years are omitted. Ben-Taher (2024) likewise identifies macroeconomic consequences of Libya’s oil-sector crises, but his quarterly structural analysis focuses on revenue disturbances and monetary variables. The studies are complementary: ours documents conditional fiscal-balance associations for price and domestic output separately, whereas his analysis examines wider macroeconomic transmission. Neither comparison establishes a causal effect from the coefficients estimated here.

The hydrocarbon-revenue mechanism makes the economic interpretation more concrete even though it is not estimated here as a separate causal stage. Price and production determine key components of the value of oil available for sale, while the Libya literature describes an institutional structure in which oil income accrues predominantly to the public sector and finances both current and development spending. The broader oil-exporter literature likewise treats government revenue as the first fiscal point at which an oil disturbance becomes visible. These considerations support the interpretation of the direct shock coefficients without turning the revenue channel into an additional empirical claim.

The next step in the mechanism requires particular caution because hydrocarbon revenue and the fiscal balance are linked through the budget identity. A regression between them would therefore contain an accounting component alongside any behavioral response. The final balance also depends on expenditure, non-hydrocarbon revenue, financing, and other budget components, so the economic mechanism is richer than a one-for-one revenue movement. For this reason, the paper does not use a revenue–balance regression as evidence of causal mediation.

This distinction helps place the findings alongside Farzanegan (2011) and Hamdi and Sbia (2013). Their results show why the expenditure side of the budget can change the fiscal consequence of an oil-revenue shock. Some expenditure categories adjust more readily than others, and current commitments can remain elevated when receipts weaken. The present model does not disaggregate Libyan expenditure and therefore cannot claim to identify expenditure rigidity directly. The literature supplies a plausible mechanism; the estimated persistence in the fiscal balance supplies evidence that adjustment is not instantaneous. Keeping those two statements separate is important.

The persistence coefficient is large enough to matter economically. With $\rho = 0.7187$, only about 28 percent of the remaining disturbance is corrected within a year. Fiscal conditions therefore carry forward. This persistence can reflect expenditure commitments, delayed revenue adjustment, institutional frictions, financing choices, or some combination of them. The model is not designed to allocate the coefficient among those mechanisms. Its contribution is to show that oil shocks enter a fiscal system whose previous condition continues to influence the present one.

The difference between the short-run and long-run evidence deserves equal emphasis. Both oil shocks are clearly associated with the current fiscal balance, but the implied long-run multipliers are less precisely estimated. A tempting response would be to treat the positive point estimates as confirmation of durable effects. The confidence intervals do not justify that degree of certainty. The stronger conclusion is narrower and, in this sample, more credible: Libya's fiscal position reacts quickly to price and production developments; the exact cumulative magnitude and duration of those effects remain harder to pin down.

The robustness exercises add confidence without turning a small sample into a large one. Removing selected influential years does not reverse the central coefficients. The residual diagnostics are reassuring, and CUSUM does not reveal a detectable instability under the test used. These checks reduce the likelihood that the baseline result is a simple artifact of one exceptional observation or an obvious specification failure. They cannot rule out every form of structural change, especially in a period as institutionally turbulent as 2010–2023. The appropriate response is not to dismiss the evidence, but to state its boundary accurately.

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Seen together, the results identify two layers of fiscal vulnerability. The first comes from outside the domestic economy through the world oil price. The second comes from the ability to maintain physical production and exports. Both feed an oil-dependent revenue base, while fiscal persistence means that the budget does not reset immediately after the shock passes. This combination helps explain why stabilization in Libya cannot be reduced to forecasting the oil price. Production continuity and the management of revenue windfalls and shortfalls are part of the same fiscal problem, even though they operate through different mechanisms.

The paper's contribution should therefore be presented with confidence but within a defined perimeter. It does not offer a complete structural model of Libya's public finances, and it does not identify a fully causal mediation chain from oil shocks through revenue to the fiscal balance. It does show, with a deliberately parsimonious design, that price and production shocks both matter for fiscal performance, that production risk cannot be subsumed under price risk, and that fiscal adjustment is persistent rather than immediate. The revenue analysis supports the mechanism behind those findings. Given the available data, that is a substantive result rather than a limitation disguised as one.

7. Policy Implications

The policy implication of separating price from production shocks is straightforward but important. Libya faces an external oil-price risk that fiscal authorities cannot control, and a production risk that is more closely connected to domestic disruptions, operational constraints, and the continuity of oil-sector activity. A fiscal framework designed only around assumptions about the international oil price would therefore leave a major source of revenue volatility insufficiently recognized. Budget preparation and medium-term fiscal scenarios should stress-test price and production paths separately rather than treating oil exposure as a single aggregate disturbance.

The estimated fiscal persistence adds a second consideration. With a lag coefficient of about 0.72, fiscal disturbances do not disappear within one budget year. This makes temporary oil windfalls a weak basis for permanent expenditure commitments and increases the value of mechanisms that separate current spending decisions from short-lived oil conditions. The results are consistent with maintaining precautionary fiscal buffers, using conservative oil assumptions, and strengthening multi-year expenditure planning. These recommendations follow from the volatility and persistence documented in the paper; they should not be read as identifying a unique optimal fiscal rule.

Production risk also changes the emphasis of stabilization policy. A favorable world price cannot fully protect the budget when domestic output falls sharply. Improving the resilience of oil production and the institutions surrounding the flow of oil receipts can therefore have fiscal-stabilization value in addition to their direct production benefits. Over a longer horizon, a broader non-hydrocarbon revenue base would reduce the degree to which both external price movements and domestic production interruptions are transmitted to the public finances.

8. Conclusion

This paper examined the fiscal effects of oil shocks in Libya by separating changes in the international oil price from changes in domestic oil production. That separation is central to the Libyan case. Price shocks capture an external source of volatility, whereas production shocks can reflect domestic interruptions capable of weakening fiscal resources even when international prices are supportive. Using annual data for 2010–2023 and a parsimonious dynamic model, the analysis finds that both shocks are positively associated with the fiscal balance in the short run.

Three results stand out. First, the fiscal balance is strongly persistent: the estimated lag coefficient of 0.7187 indicates that fiscal conditions carry over substantially from one year to the next. Second, the oil-price-shock coefficient is positive and statistically significant in the preferred specification. Third, the production-shock coefficient is also positive, highly significant, and remains notably stable when 2015, 2017, and 2023 are excluded individually. The evidence therefore supports treating production risk as a distinct fiscal vulnerability rather than as a secondary detail of oil dependence.

The estimated long-run multipliers are positive, but their confidence intervals include zero and are much less informative than the contemporaneous coefficients. The residual diagnostics and recursive CUSUM test do not reject the relevant null hypotheses; the small sample nevertheless limits their ability to detect misspecification or instability. Accordingly, the findings are best interpreted as conditional dynamic associations, not as a fully identified causal response.

The broader implication is that fiscal stabilization in Libya should recognize two oil risks rather than one. Buffers, conservative budgeting, and medium-term expenditure planning are relevant to international price volatility, but they are not sufficient if production disruptions are ignored. The results also point to the value of reducing the budget's structural dependence on hydrocarbon receipts over time. Future research could extend the analysis as longer consistent fiscal series become available, test richer asymmetries between favorable and adverse shocks, and examine more directly the institutional mechanisms linking production interruptions, realized oil receipts, and expenditure adjustment.

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Compliance with ethical standards

Disclosure of conflict of interest

The authors declare that they have no conflict of interest.

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