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Commodity Price Volatility and Fiscal Balance in Commodity-Exporting Countries

Mahdieh Rezagholizadeh [a*], Majid Aghaei[a], Mehrdad Zaghi Saroukolaee[a]

a. Faculty of Economics and Administrative Sciences, University of Mazandaran, Babolsar, Iran.

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Abstract

Fiscal balance serves as a key indicator of the effectiveness of fiscal policy and a fundamental tool for governments in achieving development goals and ensuring macroeconomic stability. This role is especially crucial in commodity-exporting countries, where fiscal outcomes are highly sensitive to commodity price fluctuations, highlighting the need for prudent, countercyclical fiscal management. Commodity price volatility, closely linked to the real sector, can impact fiscal balance through changes in income and expenditures. This study examines the effect of commodity price volatility on the fiscal balance of selected commodity-exporting countries from 2004 to 2021. The relationships between variables are estimated using the Pooled Mean Group (PMG) technique. The findings reveal a negative and significant short-run relationship between commodity price volatility and fiscal balance, while the long-run effect is positive and significant. Moreover, inflation has a positive effect in the short run but turns negative in the long run. The unemployment rate has a significant negative impact in the long run but is statistically insignificant in the short run. Using a Panel Vector Error Correction Model (P-VECM), the study confirms short-run bidirectional causality between commodity price volatility and fiscal balance and a long-run unidirectional causal flow from volatility to fiscal balance. These results underscore the importance of adopting robust fiscal frameworks—such as countercyclical rules, sovereign wealth funds, and market-based instruments like futures and options—to manage revenue volatility and strengthen fiscal resilience in commodity-exporting countries

Highlights

- This study explores Commodity Price Volatility effect on Fiscal Balance in Commodity-Exporting Countries long-run and short-run.
- The commodity price volatility has been derived from commodity terms of trade specific to each country.
- Based on results, commodity price volatilities have positive impact on fiscal balance in long-run and also negative effect in short-run.

* m.gholizadeh@umz.ac.ir
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1. Introduction

Fiscal balance, broadly defined as the difference between a government's revenues and expenditures, serves as a fundamental indicator of a country's fiscal health and its capacity to implement macroeconomic policy (OECD, 2021). According to the OECD, a positive fiscal balance indicates a budget surplus, while a negative balance reflects a fiscal deficit, requiring the government to borrow in order to finance its spending. The International Monetary Fund (IMF) further distinguishes between several types of fiscal balances—gross, cyclically adjusted, structural, and primary fiscal balance. Fiscal balance is a fundamental indicator of a government's fiscal discipline and its ability to align public spending with available resources. It reflects whether expenditures are financed through stable revenue streams or through borrowing. A sound fiscal position supports macroeconomic stability, helps contain public debt, and provides the flexibility to respond to adverse economic conditions. Conversely, sustained fiscal deficits can erode fiscal space, raise borrowing costs, and limit the government's capacity to invest in growth-enhancing and social programs (UNCAD & FAO, 2017). These challenges are particularly pronounced in commodity-exporting economies, where revenue volatility linked to global price volatilities can make fiscal management more difficult (Sturm et al. 2009). Examining the behavior of fiscal balance under such conditions is crucial for developing policies that strengthen fiscal resilience and long-term stability.

Commodities are raw materials used in producing goods and are considered main goods, such as agricultural products. The commodity market is a segment of the financial market where these goods are traded and is typically divided into two groups: hard commodities and soft commodities. Hard commodities include energy commodities like oil and gas, and precious metals like gold, silver and platinum. Soft commodities consist of agricultural products like soy, coffee, and cotton. Since these goods can be used both directly and indirectly, changes in commodity prices can affect the marginal price of many goods (Ghaderi & Shahrazi, 2020). Commodity price volatility is typically high due to the inherent characteristics of these markets and the influence of various internal and external factors. Some of these factors include changes in global supply and demand, geopolitical developments, climate changes, and economic policies of countries. These volatilities can directly affect the economies of commodity-exporting countries and lead to changes in their fiscal balance.

The role of commodity price fluctuations in increasing budgetary expenditures, creating uncertainty, causing debt unsustainability, and influencing economic policies has raised concerns about managing fiscal policies and government debt. Due to economic globalization, these shocks and volatilities can affect global markets, meaning that any volatility, change, or unpredicted shock impacts not only a country's economy but also the global economy.

Events in recent decades highlight the complex and volatile relationship between commodity markets and economic activity. For example, during the COVID-19 pandemic, crude oil experienced its sharpest one-month price decline

ever due to a sharp fall in global demand. Furthermore, the war in Ukraine caused disruptions to commodity markets, leading to changes in trade costs and procedures. This disruption illustrated the interconnectedness of commodity markets, as price increases, especially in the energy sector, led to higher production costs, negatively impacted food imports, and raised concerns about food security. These incidents also contributed to global inflation, decreased salaries and incomes, and lowered human development and social welfare levels (Baffes & Nagle, 2022).

The income and expenditures of commodity-exporting countries are heavily based on commodity exports; therefore, commodity price volatilities can significantly impact their fiscal balance through changes in incomes and expenses. Cespedes & Velasco (2014) demonstrate that fiscal balance improves with an increase in commodity prices. Conversely, studies by Alley (2016) and Ezeaku et al. (2021) found that in commodity-exporting countries, especially low-income ones, expenditures increase with rising commodity prices, leading to fiscal balance deterioration. The economic and institutional structure of countries is a significant factor that influences the impact of commodity price volatility on fiscal balance. Countries with stronger financial and budgetary systems generally have greater capacity to manage volatilities and can use various financial and policy tools to mitigate the negative effects of these volatilities.

Figure 1 shows the monthly trend of All Commodity Price Index from 2004 to 2021. It highlights price booms and busts during the 2007-2008 global financial crisis, the 2010-2011 financial crisis in EU countries due to the government debt crisis, and the price declines during the COVID-19 pandemic in 2019.

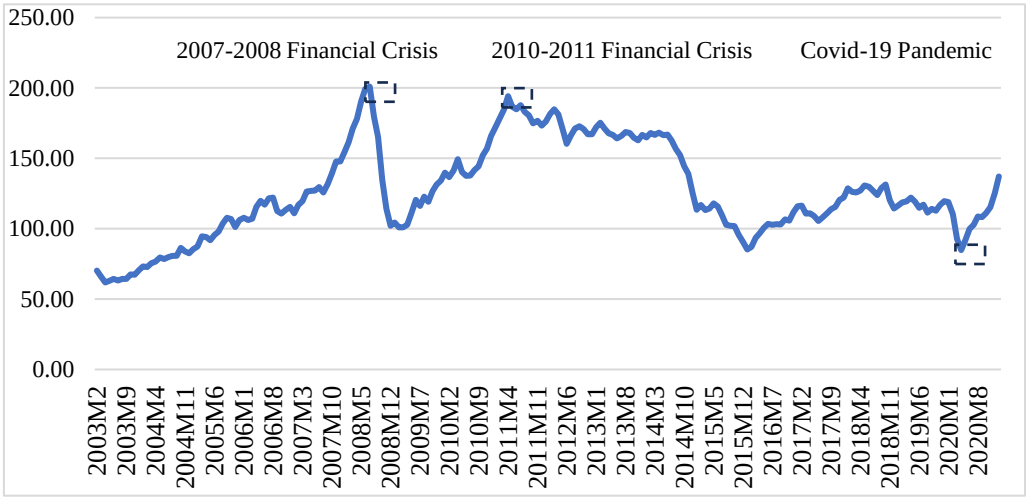

Figure 1. Monthly trend of All-Commodity Price Index

Source: *IMF*

Oil prices saw a 60% decline post-COVID-19 but have not yet returned to pre-pandemic levels. Metal prices, initially impacted, rebounded swiftly due to the unexpected strength of China's economic recovery. Conversely, agricultural and food prices have remained largely stable, driven by adequate crop supplies and minimal disruption to food demand. However, agricultural commodity markets are also influenced by energy prices, as energy is crucial for the production of grains and oilseeds. It directly impacts production by affecting fuel prices and indirectly through the use of fertilizers and other chemical inputs (Baffes, 2021). Post-COVID-19, significant disruptions have contributed to the global economic slowdown and volatility in commodity prices, particularly crude oil, which have been influenced by macroeconomic variables and non-economic factors such as geopolitical tensions, the Gulf War, the COVID-19 pandemic (Bildrici et al. 2020), and the Ukraine-Russia conflict.

Based on insights from the existing theoretical and empirical literature, a comprehensive conceptual framework is adopted to delineate the key channels through which commodity price volatility impacts fiscal balance in commodity-exporting economies. The model is built on three interrelated channels—Income, Expenditure, and Debt Sustainability—and incorporates moderating variables such as institutional quality, stabilization mechanisms, and fiscal governance frameworks.

1.1 Income Channel

Commodity price booms typically generate windfall revenues via increased export earnings, which are directly channeled into government revenues through taxation, royalties, or profits from state-owned enterprises. In economies with robust fiscal framework and countercyclical policies, this additional revenue can strengthen fiscal buffers, support long-term investment, and reduce debt burdens.

However, in countries with insufficient frameworks, this income increase leads to expansionary fiscal measures that may not correspond with long-term fiscal sustainability. This path dependency is essential: whereas revenue increases can theoretically improve fiscal balance, their actual effect relies on governmental management and allocation of those funds.

1.2 Expenditure Channel

This channel reflects the political economy dynamics surrounding commodity windfalls. Rising commodity prices often raise public expectations and increase political pressure on governments to spend more—particularly on current expenditures (e.g., subsidies, public wages) and low-efficiency capital projects. This spending surge, often referred to as the "voracity effect[1]", is

[1] The voracity effect, originally introduced by Tornell and Lane (1999), refers to the paradoxical situation where a sudden influx of resource-driven income triggers intensified competition among interest groups within a country. This leads to increased rent-seeking behaviors, corruption, inefficient resource allocation, and ultimately impedes rather than enhances economic growth and stability.

especially prevalent in low-income or institutionally weak countries where budget constraints are not strictly enforced.

A key vulnerability of this channel lies in the rigidity of government expenditures. Once established, such expenditures are difficult to reverse, even during price busts. Consequently, fiscal discipline deteriorates, and budget volatility increases, undermining the resilience of public finance systems.

1.3 Debt Sustainability Channel

Commodity downturns typically result in sharp revenue contractions. Given that much of the expenditure structure remains fixed—especially in countries with weak automatic stabilizers—governments are often compelled to finance deficits through borrowing. Over time, this reliance on debt to mitigate fiscal shocks can lead to unsustainable public debt levels, increase vulnerability to interest rate changes, and reduce fiscal space for future crises.

This channel is particularly damaging in countries with limited access to international capital markets or those subject to high-risk premiums, leading to a fiscal trap where new borrowing is used to service old debt.

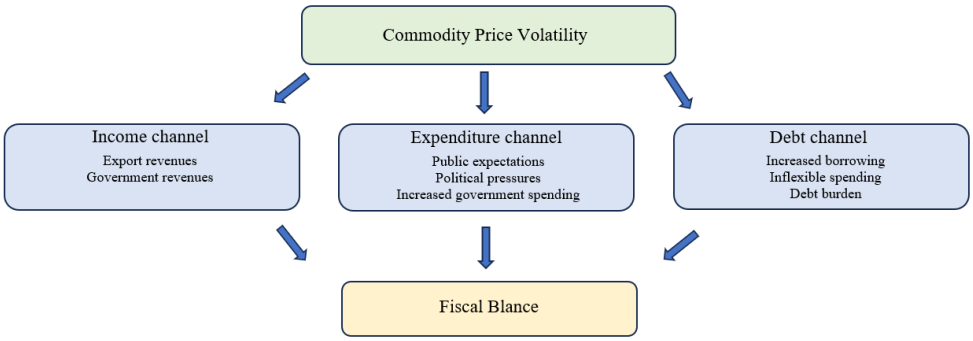

Figure 2. Conceptual Framework
Source: *Authors Research*

Figure 3 and Figure 4 shows primary fiscal balance and commodity price volatilities of fuel-commodity exporters. The graphs highlight the fiscal volatility of fuel-exporting countries in response to commodity price fluctuations. The Primary Fiscal Balance graph shows that countries like Saudi Arabia and Norway experience stronger fiscal positions during oil price booms but face significant volatility during downturns, especially around the 2008 oil crisis. In contrast, nations such as Iran, Algeria, and Colombia display more erratic fiscal balances, indicating weaker fiscal planning and vulnerability to price shocks. The Commodity Price Volatility graph further underscores the challenges these nations face, with Saudi Arabia experiencing the highest volatility, followed by Iran and Norway. However, Norway's fiscal stability, supported by its sovereign wealth fund, exemplifies how effective fiscal frameworks can mitigate the impact of price

fluctuations. These findings align with Richaud (2019), which emphasizes the importance of countercyclical fiscal policies and robust fiscal frameworks to enhance resilience against commodity price shocks.

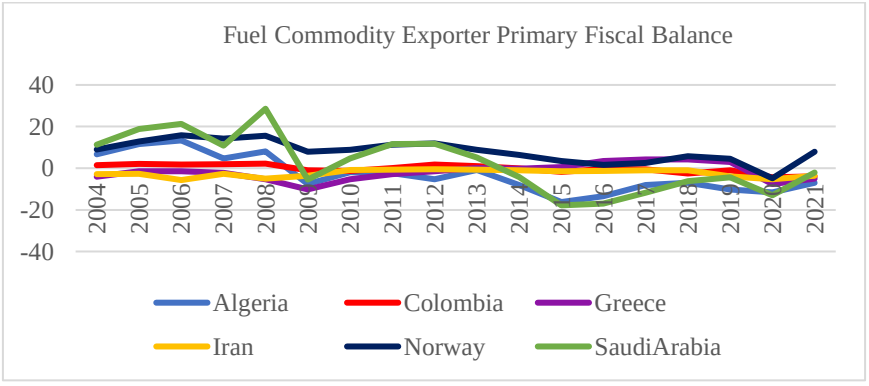

Figure 3. Fuel Commodity Exporter Primary Fiscal Balance
Source: *IMF*

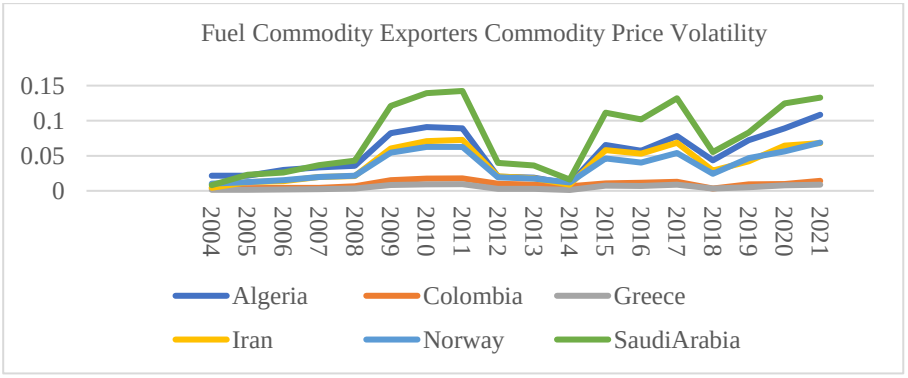

Figure 4. Fuel Commodity Exporter Commodity Price Volatility
Source: *Author's calculation*

Figure 5 displays the primary fiscal balance of non-fuel commodity-exporting countries. Most countries in the sample maintain fiscal positions close to balance, with moderate fluctuations over time. Brazil stands out with a significant deterioration in 2009, likely reflecting the impact of the global financial crisis, followed by a sharp rebound and another fiscal dip post-2018. In contrast, Chile, Peru, and Australia demonstrate relatively stable fiscal outcomes, suggesting more disciplined fiscal management and lower sensitivity to commodity-driven revenue cycles.

Figure 6 also shows commodity price volatility for the same group of countries. Overall, non-fuel exporters exhibit lower volatility compared to fuel exporters, reflecting greater diversification in their export bases. Nonetheless, certain countries such as Iceland and Ecuador experienced noticeable volatility spikes around 2011–2014, likely due to exposure to specific commodities.

Meanwhile, countries like Australia and New Zealand show minimal fluctuations, indicating a more stable export structure. These differences highlight the varying degrees of exposure to global price shocks among non-fuel commodity exporters.

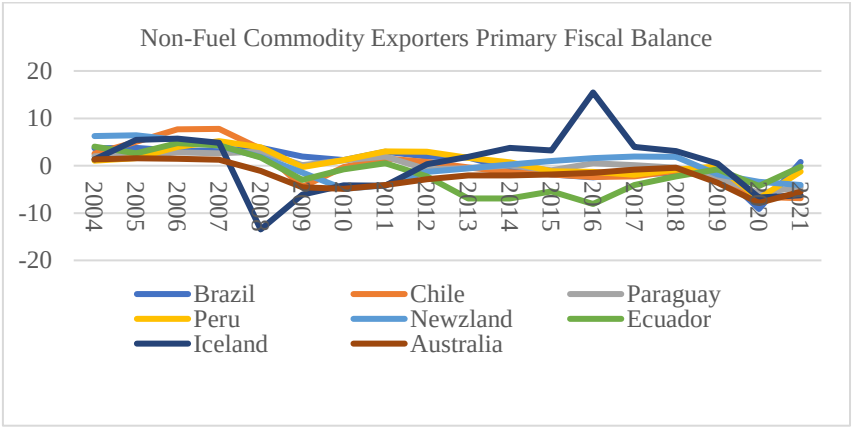

Figure 5. Fuel Commodity Exporter Primary Fiscal Balance
Source: *IMF*

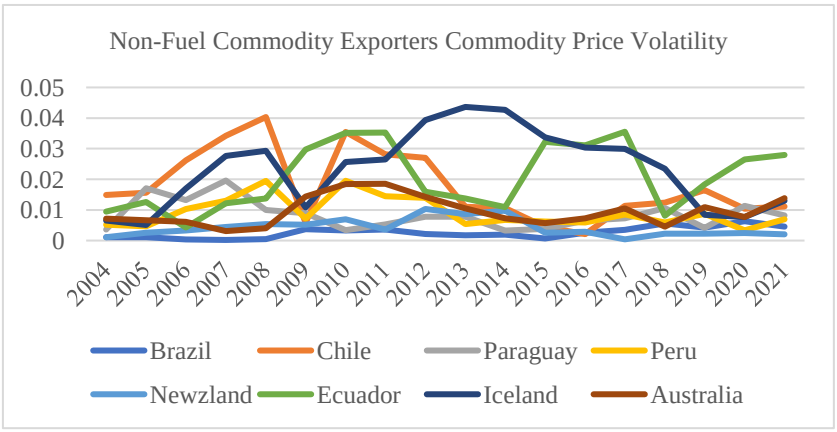

Figure 6. Fuel Commodity Exporter Commodity Price Volatility
Source: *Author's calculation*

This study contributes to the existing literature in several important ways:

(i) First, unlike many prior studies that focus narrowly on oil, this paper adopts a broader, multi-commodity perspective. It constructs a country-specific Commodity Price Volatility Index using the approach of Gruss & Kebhaj (2019) and Majumder et al. (2022), which combines international commodity prices with country-level net export weights scaled by GDP. This method captures country-specific exposure to price fluctuations across a wide range of commodities, allowing for a more representative and policy-relevant analysis—especially for economies that are not predominantly oil exporters.

(ii) Second, the empirical framework applies the Pooled Mean Group (PMG) estimator within a dynamic panel setting. This allows the analysis to distinguish between short-run dynamics and long-run equilibrium relationships across heterogeneous countries. Compared to static or country-specific models, this approach enables richer cross-country comparisons and offers a more credible assessment of long-term fiscal adjustment mechanisms. This dual-layered design allows for more precise inference on how fiscal responses to commodity price volatility differ in short-run and long-run.

(iii) Third, the study covers the period 2004–2021, which includes multiple episodes of global stress, such as the 2008 financial crisis and the COVID-19 pandemic. This broad time horizon enables the analysis to assess fiscal resilience[1] under severe external shocks and contributes to a more up-to-date understanding of fiscal policy in volatile global environments.

(iiii) Fourth, Empirically, this study provides a refined understanding of how key macroeconomic variables influence fiscal balances across different income groups of commodity-exporting countries[2], linking these findings to actionable fiscal strategies tailored to both high- and low-income contexts. The selection of countries was made to provide a broad and diverse representation of commodity-exporting nations. These countries, spanning both high- and low-income economies, offer a rich backdrop for examining the influence of commodity price volatility on fiscal balances. The diversity in economic structures, income levels, and commodity dependence across these nations allows for a comprehensive overview of the macroeconomic dynamics at play. This study, therefore, serves as an insightful exploration of how fluctuations in commodity prices affect fiscal outcomes, providing a holistic understanding of fiscal responses in varying economic contexts. The findings aim to inform fiscal strategies that are tailored to the distinct needs of different income groups within the global commodity-exporting sector.

The remainder of the paper is structured as follows. Section 2 reviews the existing literature on the fiscal effects of commodity price shocks, with a focus on recent advances in measuring country-specific exposure to global commodity markets. Section 3 describes the data, the construction of the Commodity Price Volatility Index, and outlines the empirical strategy, including the dynamic panel model with pooled mean group (PMG) estimation. Section 4 presents the main empirical findings, highlighting both short-run and long-run effects of commodity price volatility on fiscal balance. Finally, Section 5 concludes and discusses the policy implications for commodity-dependent economies aiming to enhance fiscal resilience.

[1] Fiscal resilience refers to the government's ability to absorb external shocks—such as commodity price volatility—without facing fiscal instability, unsustainable debt accumulation, or drastic cuts to public services.

[2] Including: Norway, New Zealand, Chile, Colombia, Iceland, Greece, Australia, Algeria, Brazil, Iran, Saudi Arabia, Paraguay, Peru and Ecuador

2. Literature review

Natural resources and commodities, both agricultural and industrial, remain fundamental to economic activity, either as final goods or as intermediate inputs in production processes. As global economies expand and per capita incomes rise, demand for commodities intensifies, contributing to persistent price increases and heightened volatility. Consistent price increases and volatility demonstrate the importance of commodities. Commodity price volatility introduces uncertainty and risk for producers, traders, consumers, and governments, potentially leading to sub-optimal decisions (IMF & UNCAD, 2011).

In early 2008, a sharp surge in inflation, driven largely by accelerating food and energy commodity prices, caused substantial challenges for policymakers worldwide. Persistent fiscal deficits and high public debt stocks created pressure on public budgets. Price volatility, particularly from commodity fluctuations, exacerbated financial pressures on public budgets in the years preceding the global financial crisis. Rising prices had substantial macroeconomic and budgetary impacts, as well as distributional effects, likely contributing to more skewed income distribution (Albers & Peeters, 2011).

Government spending plays a key role in fiscal policies. Given that government spending constitutes a large share of aggregate demand and that financing it often depends on income from commodity exports in commodity-dependent countries, price instability and volatility can lead to instability in aggregate demand and economic growth. Revenues from commodity exports are crucial for financing imports and public spending in commodity- dependent developing countries (CDDCs) (Tröster & Küblböck, 2020). Price shocks significantly affect - government finances, and because commodity price volatility is accompanied by uncertainty, it can exacerbate budgetary uncertainty and threaten debt levels. In developing countries, this issue can impact infrastructural and social programs.

In commodity-dependent developing countries (CDDCs), revenues from commodity exports significantly finance imports and public expenditures, underpinning economic stability (Tröster & Küblböck, 2020). Commodity price shocks exacerbate budgetary uncertainties, elevating debt sustainability risks and negatively impacting critical infrastructure and social programs. Kumah & Matovu (2005) highlighted such fiscal vulnerabilities, illustrating how Central Asian economies' reliance on volatile commodity revenues increased public finance instability. Similarly, UNCTAD and FAO (2017) noted substantial revenue declines in African CDDCs due to falling commodity prices post-2011, prompting increased borrowing and exacerbating fiscal stress.

The decline in commodity prices has had the most severe impact on countries that relied on a high minimum oil price to sustain a balanced budget. Due to the decrease in oil prices throughout late 2015 and 2016, several oil-exporting nations, including Algeria, Nigeria, and Saudi Arabia, had to reduce their expenditures and government investments. The decline in commodity prices similarly affected countries exporting other goods. For instance, Chile, the largest

exporter of copper, experienced a significant deviation in revenue from budget projections. It's evident that a decline in funding for public spending, combined with changes in oil prices due to political and social factors, leads to a reduction in institutional quality. Social expectations, political pressures, and powerful interest groups force governments to increase spending during price booms. The primary challenge for governments is that most expenses are not flexible and cannot be reduced during periods of declining revenues (Rasheed, 2023; Ahmad & Masan, 2015).

Large increases in public capital spending during boom periods are often non-productive and yield low returns (Talvi & Vegh, 2000). In contrast, a negative shock usually forces downward adjustments in government expenditures, which can be costly. Cutting current expenditures is unpopular due to its social consequences. Furthermore, reducing capital expenditures hampers public projects, lowers the efficiency of initial investments, and leads to societal costs (Omojolaibi & Egwaikhide, 2014). Bleaney & Halland (2016) examine whether resource-rich developing countries exhibit weaker fiscal discipline relative to their resource-poor counterparts. Using a panel of low- and middle-income countries over 1996–2012, the authors employ comparative regressions incorporating political risk indicators and macroeconomic controls. They find that fuel exporters maintain stronger fiscal balances, with fiscal reactions to commodity price increases being significantly positive but lagged. In contrast, metals exporters show no such clear pattern. Their analysis underscores the importance of political institutions and exchange rate regimes in shaping fiscal behavior.

Murphy & Villafuerte (2010) conduct a comparative assessment of fiscal policy responses in seven Latin American and Caribbean (LAC) countries exporting non-renewable resources over the 2003–2009 cycle. Using primary balances and indicators of fiscal sustainability, they demonstrate that while most countries pursued procyclical policies during the boom years, those that maintained conservative stances were better positioned to adopt countercyclical responses during the subsequent downturn. In 2008, the fiscal balance improved by 2.5% of GDP with the rise in oil prices. However, about a dozen countries saw a decline in fiscal balances, and three (Iran, Ecuador, and Yemen) shifted from surpluses to deficits. The analysis reveals limited effectiveness of formal fiscal rules or resource funds in constraining discretionary spending, suggesting institutional frameworks alone are insufficient without broader political and economic commitment. Their findings underline the critical role of policy discipline in reducing fiscal vulnerability to resource price fluctuations.

Spatafora & Samake (2012) provide compelling evidence on the asymmetric fiscal effects of commodity price shocks, particularly across exporting versus importing economies. Using a panel of low- and middle-income countries, they show that positive commodity price shocks tend to improve fiscal balances in exporting countries through enhanced revenues, while the fiscal responses in importing economies are muted or even mildly adverse due to inflationary and

subsidy-related pressures. Importantly, their analysis also reveals that the composition of fiscal adjustment—whether via spending restraint or revenue gains—varies significantly with the nature of the commodity shock. The study indicates that an increase in commodity export prices typically results in higher public spending, with the most significant response seen in low-income commodity-exporting countries (LICs). Additionally, tax revenues tend to rise in the short term. In LICs, this situation often leads to a deterioration in the fiscal balance. These findings emphasize the importance of considering the structural exposure of countries to fluctuations in global commodity markets.

Kumah & Matovu (2005) investigate the macro-fiscal consequences of transitory commodity price shocks in oil-exporting versus non-oil economies, focusing on the Central Asian region. Employing a structural VAR framework for the 2000–2004 period, they assess how tax regimes mediate the transmission of shocks. The study reveals that oil-exporting countries experience significant short-run fiscal surpluses during commodity booms, yet face pronounced risks of fiscal instability post-boom, especially under passive tax systems. The authors emphasize the role of proactive fiscal frameworks in managing windfall revenues effectively, highlighting the temporal mismatch between commodity income surges and sustainable expenditure paths. The authors proposed that the unpredictability and instability of commodity prices make fiscal policy management more challenging.

While several prior studies (Bleaney & Halland, 2016; Murphy et al., 2010) found that rising commodity prices typically strengthen fiscal balances in commodity-exporting countries—suggesting a countercyclical fiscal pattern—Majumder et al. (2022) shift the focus toward price volatility (All-Commodity Price Index Volatility) rather than price levels. Using a dynamic panel dataset of 108 countries (1993–2018), by applying OLS Model they find that increased commodity price volatility significantly worsens fiscal balances, particularly in commodity-exporting economies, where a one-standard-deviation rise in volatility leads to a 0.07 percentage point decline in the fiscal balance as a share of GDP. In contrast, for commodity-importing countries, the effect is smaller and statistically insignificant. The study challenges oil-centric literature by broadening the analysis to a multi-commodity context where volatility—rather than price booms—drives fiscal deterioration. In Table1 we summary of primary previous works with details:

Table 1. Overview of Empirical Studies on Commodity Prices and Fiscal Policy

Authors (Year)	Model/Methodology	Time Period	Countries/Regions	Key Findings
Bleaney & Halland (2016)	comparative regressions with political and macroeconomic controls	1996-2012	Low and Middle-income countries	Fuel exporters have stronger fiscal balances; responses to price increases are lagged; institutions and exchange regimes matter
Murphy & Villafuerte (2010)	Primary balance analysis and fiscal sustainability indicators	2003-2009	Seven Latin American and Caribbean countries	Some countries maintained countercyclical policies; fiscal rules alone insufficient without political commitment
Spatafora & Samake (2012)	Panel data analysis of asymmetric commodity shock effect	1990-2010	Low and Middle-income countries	Positive commodity price shocks improve fiscal balance in exporters; LICs show spending-led deterioration
Kumah & Matovu (2005)	Structural VAR model	200-2004	Central Asia	Revenue surges during booms; instability post-boom; active frameworks needed for managing windfalls
Majumder et al. (2022)	OLS on panel dataset	1993-2018	108 countries	Volatility (not just price levels) worsens fiscal balance in exporters; effect insignificant for importers
Alley (2016)	Vector Error Correction Model (VECM)	1990-2013	18 oil-exporting countries (e.g., Nigeria, Saudi Arabia, Iran, Brazil, UAE, etc.)	In the short run, oil price volatility reduces the primary fiscal balance (PFB); in the long run, governments adjust, and PFB improves. Fiscal policies are not procyclical overall, but are sensitive to oil price shocks.

Source: *Authors research*

This paper reviews key literature on the impact of commodity price fluctuations on fiscal policy, emphasizing how price volatility affects fiscal behavior in commodity-exporting economies. Previous studies have highlighted that commodity price booms often improve fiscal balances, while price shocks can introduce instability, with responses varying based on a country's economic structure and political context. Notably, studies by Bleaney & Halland (2016) and Murphy & Villafuerte (2010) focus on the importance of political institutions and fiscal policies, while Kumah & Matovu (2005) and Majumder et al. (2022) emphasize the need for proactive fiscal frameworks to manage volatility. However, much of the literature is centered on oil-exporting countries, limiting insights into broader commodity price impacts.

In many previous studies, the exclusive focus on oil prices as the main indicator of commodity price fluctuations has resulted in findings that are specifically aligned with the structures of oil-dependent economies. However, many developing economies and even some developed countries have a mix of export commodities, including metals, agricultural products, and energy, each of which may generate different volatility patterns and have distinct transmission channels for fiscal effects. The use of a composite commodity price index in this study enables a more precise examination of the simultaneous and interactive effects of these volatilities on government fiscal balances. From this perspective, the current approach offers a more comprehensive understanding of countries' fiscal resilience to external shocks. This viewpoint forms the theoretical and logical foundation for the hypotheses of this research.

This study distinguishes itself by adopting a multi-commodity perspective, using a novel Commodity Price Volatility Index that combines international price trends with country-specific export weights, making the analysis more representative of non-oil-dependent economies. The empirical framework applies the Pooled Mean Group (PMG) estimator, which allows for a distinction between short- and long-term fiscal responses, offering richer insights than static models. Additionally, the study covers the 2004–2021 period, capturing fiscal resilience during global stress events like the 2008 financial crisis and the COVID-19 pandemic.

3.Model and Methodology of Research

3.1. Model and Data

This paper investigates the impact of commodity price volatilities on the fiscal balance of OECD commodity exporting countries and selected well-known commodity exporters, including, Norway, New Zealand, Chile, Colombia, Iceland, Greece, Australia, Algeria, Brazil, Iran, Saudi Arabia, Paraguay, Peru and Ecuador. These countries were chosen based on the UNCAD (2021) report. Collectively, these nations export a broad array of products, including oil, natural gas, coal, agricultural goods, and mineral resources, allowing the study to capture the effects of price volatility across different commodity sectors and levels of economic development.

Based on the conceptual framework of fiscal balance transmission, three main channels are identified: (1) the revenue channel, through which commodity price volatility affects government income; (2) the expenditure channel, where volatility leads to instability in public spending; and (3) the debt sustainability channel, where volatility impacts borrowing needs and fiscal planning. In our empirical model, these channels are represented by specific variables: commodity price volatility (CPV) is linked primarily to the revenue channel, as it directly affects resource-based income; CPI inflation (LINF) captures the expenditure-side adjustments, particularly in terms of real public spending and automatic stabilizers; and unemployment rate (UNM) serves as a proxy for cyclical conditions that affect both public revenue (via lower taxes) and spending (via social support), reflecting pressures on debt sustainability. This mapping allows us to test each channel's short- and long-run implications for fiscal balance.

The basic model is based on previous studies by Majumder et al. (2022), and Tujula & Wolswijk (2004) and is specified as:

$$FB_{it} = \beta_0 + \beta_1 CPV_{it} + \beta_2 LINF_{it} + \beta_3 UNM_{it} + \varepsilon_{it} \quad (1)$$

Where:

i represents country, and t represents the period.

FB: is the primary net lending/borrowing variable representing the fiscal balance. According to the OECD (2017), Primary Fiscal Balance , also referred to as net lending/borrowing of the general government, is the difference between total government revenue and expenditure, excluding net interest payments on general government liabilities. It measures the extent to which the general government is either providing financial resources to other sectors in the economy and nonresidents (net lending) or utilizing financial resources generated by other sectors and nonresidents (net borrowing) (Fourkan, 2021).

CPV: the CPV is a country-specific index that captures changes in a nation's commodity trade prices relative to its economic size. It measures the income effects arising from fluctuations in international commodity prices by weighting real price changes of 45 commodities according to each country's average net exports over the period 1980–2021. The index is deflated using the IMF's Manufacturing Unit Value (MUV) and is rebased to 2012 = 100. Higher CPV values indicate favorable movements in a country's commodity trade prices relative to its GDP. In line with theoretical expectations, the coefficient of commodity price volatility (CPV) is anticipated to be negative. High volatility in commodity prices disrupts fiscal planning and introduces uncertainty in revenue projections, thereby reducing fiscal stability. This aligns with findings in the literature suggesting that volatility undermines fiscal discipline, particularly in commodity-dependent economies.

LINF: represents the annual percentage changes of the Consumer Price Index (CPI), which measures inflation. Inflation's impact on the primary balance can be ambiguous. As it's been discussed in previous studies such as Zeng (2014), Abiad & Ostry (2005), the primary fiscal balance may improve because of the Patinkin

effects, if expenditures are fixed in nominal terms or the bracket creep effects on tax revenues. On the other hand, higher inflation, as an alternative method for the government to lower its real debt burden, could reduce the need to run high primary balances and thus lead to a smaller primary fiscal balance (Zeng, 2014). A positive short-run effect on the fiscal balance is expected, consistent with the "Patinkin effect." In the short term, nominal revenues tend to adjust more rapidly than expenditures due to price rigidities, temporarily improving the fiscal stance. However, in the long run, higher inflation can increase the cost of public expenditures and reduce fiscal space, thereby exerting a negative impact on the fiscal balance. This dual effect of inflation has been widely documented, particularly in the context of developing and emerging economies.

UNM, unemployment rate gives the number of unemployed persons as a percentage of the labour force (Mara, 2012). Unemployment rate has been used in researches as a measurement of fiscal balance responsiveness to macroeconomic conditions (Tujula & Wolswijk, 2004). Based on previous studies Unemployment is related to both sides of the budget. Reduction in the government revenues and growth of the government expenditures. Growing unemployment rate worsens the primary balance through declining tax revenues because of less income taxes and increased expenditures in the form of paid social contributions. So, unemployment has been shown to negatively affect fiscal balance by reducing government revenues and increasing expenditures (Mihóková et al., 2019; Mara, 2012). The unemployment rate (UNM) is expected to have a negative impact on the fiscal balance in both the short and long term. Higher unemployment reduces government revenue through lower tax collections and simultaneously increases expenditures due to higher social welfare and unemployment benefit payments. Table 2 shows a summary of the dataset.

Table 2. Variable Specifications and Data Sources

Variable	Describe	Period	Data source
FB	Net lending/borrowing of government as % of GDP	2004-2021	IMF
CPV	Commodity Price Volatility (country-specific commodity terms of trade indices volatility)	2004-2021	IMF
INF	Annual percent changes in consumer price index	2004-2021	World Bank
UNM	Unemployment rate (Unemployment rate)	2004-2021	IMF

Source: *IMF and World Bank*

To measure commodity price volatility at the country level, we rely on the country-specific Commodity Terms of Trade (CTOT) indices published by the International Monetary Fund (IMF), originally developed following the

methodology of Gruss & Kebhaj (2019). These indices incorporate international prices of 45 commodities, including energy (e.g., crude oil, natural gas, coal), metals (e.g., copper, aluminum, iron ore, gold), food and beverages (e.g., coffee, wheat, beef, sugar), and agricultural raw materials (e.g., cotton, rubber, wool).

The CTOT indices are constructed using fixed trade weights averaged over the period 1980–2021, with real commodity prices deflated by the IMF's Manufacturing Unit Value (MUV) index, and are rebased to 2012 (2012 = 100). Trade data underlying the weights are sourced from the UN Comtrade database, ensuring consistency with international reporting standards.

In this study, we use the CTOT indices retrieved from the IMF database and apply standard time-series techniques to derive a measure of price volatility. Specifically, we calculate the annual growth rate of the CTOT index by taking the first difference of its natural logarithm:

$$\Delta log(CTOT_{i,t}) = log(CTOT_{i,t}) - log(CTOT_{i,t-1}) \quad (2)$$

Following Majumder et al. (2022), to capture commodity price volatility, instead of using the annual standard deviation, we compute the three-year rolling standard deviation of annual growth rates. For each year t, the volatility measure σ_t is calculated as:

$$\sigma_t = \sqrt{\sum_{k=t-1}^{t+1} \frac{1}{3} \left(\Delta \log\left(\mathrm{CTOT}_{\mathrm{i,k}}\right) - \overline{\Delta \log(\mathrm{CTOT_i})}\right)^2} \quad (3)$$

where $\Delta \log\left(\mathrm{CTOT}_{\mathrm{I,t}}\right)$ represents the mean of the annual growth rates over the three-year window centered at year t. This approach enables us to smooth out short-term fluctuations while preserving the economic relevance of commodity price shocks. By employing fixed weights and net export positions, the resulting volatility measure primarily reflects external shocks rather than domestic trade dynamics, ensuring its suitability for analyzing the macroeconomic effects of commodity price volatility.

3.2. Research Methodology

The standard panel models, such as pooled OLS, fixed-effects, and random-effects models have notable limitations. For instance, pooled OLS is highly restrictive, imposing common intercept and slope coefficients for all cross-sections and, therefore, disregards individual heterogeneity. On the other hand, the fixed-effects model assumes common slopes and variance but allows for country-specific intercepts. Moreover, static panel estimators do not fully exploit the panel nature of the data by distinguishing between the short and long-run relationships (Ahmad et al., 2022). To capture the dynamics of panel data, we need models that analyze cross-sectional data over time. One such model is the GMM model (Nazari et al., 2023). Although the system GMM estimator effectively addresses endogeneity and country-specific fixed effects, it imposes identical slope coefficients across countries, assumes homogenous time effects, and requires cross-sectional independence of errors. If these conditions are

violated, the GMM method may produce inconsistent parameter estimates (Mohaddes & Raissi, 2017).

Pesaran et al. (1999) demonstrated that ARDL models are a well-established regression technique, incorporating lags of both the dependent and independent variables. However, in a panel setting, ARDL can be problematic due to bias from the correlation between mean-differenced exogenous variables and the error term. A better alternative is the Pooled Mean Group (PMG) estimator (Pesaran et al.,1999), which handles non-stationary panels by allowing for error correction and separating short- and long-run impacts. PMG permits intercepts, short-run coefficients, and error variances to differ across groups while constraining long-run coefficients to be equal (Olakojo, 2015). The use of the Pooled Mean Group (PMG) estimator, is motivated by its ability to dynamically distinguish between short-run and long-run effects in heterogeneous panel data settings. Unlike methods such as GMM or fixed-effects models—which are primarily suited for short-term analysis and impose strict assumptions regarding coefficient homogeneity—PMG allows short-run coefficients to vary across countries while constraining long-run coefficients to be homogeneous. This feature is particularly advantageous in contexts where countries may respond differently to shocks in the short run but follow similar long-term adjustment paths. The benefits of using the PMG estimator have also been highlighted in studies by Sharma & Pal (2019).

The empirical model using the PMG model proposed by Pesaran et al. (1999) is as follows:

$$\Delta y_{it} = \phi_i y_{i,t-1} + \beta_i X_{i,t} + \sum_{j=1}^{p-1} \lambda^*_{i,j} \Delta y_{i,t-1} + \sum_{j=0}^{q-1} \delta^*_{i,j} \Delta X_{i,t-j} + \gamma'_i d_i + \varepsilon_{i,t} \quad (4)$$

Where

$$\phi_i = -\left(1 - \sum_{j=1}^{p-1} \lambda_{i,j}\right), \beta = \sum_{j=0}^{q} \delta_{i,j} \quad (5)$$

And also,

$$\lambda^*_{i,j} = \sum_{m=j+1}^{p} \lambda_{i,m}, j = 1,2,\dots,p-1 \text{ and } \delta^*_{i,j} = \sum_{m=j+1}^{q} \delta_{i,m}, j = 1,2,\dots,q-1 \quad (6)$$

In the equation above, Δy_{it} , is the dependent variable and $X_{i,t}$ is the vector of explanatory variables. γ'_i is the constant term of each country, $\lambda_{i,m}$ and $\delta_{i,m}$, are the short-term coefficient of each country, $\lambda^*_{i,j}$ and $\delta^*_{i,j}$ are the short-run coefficient of all the sample countries of this research. β_i long-term coefficient of explanatory variables of the model (Nazari et al., 2023). Also, ϕ_i is the error correction term as it defines the model's dynamic stability.

4. Emperical Results and discussion

Table 3 provides a summary of the key variables, expressed as percentages. Overall, the variables demonstrate substantial variability, as reflected by the wide gaps between their maximum and minimum values. The fiscal balance averages

0.09% of GDP, ranging from a minimum of -17.85% to a maximum of 28.57%. The Commodity Price Volatility (CPV) recorded its highest value in Saudi Arabia in 2011 and its lowest in Brazil in 2007. Regarding inflation (INF, measured as the annual percentage change in the Consumer Price Index), the maximum value of 4.71% was observed in Greece (2010), while the minimum value of -1.83% occurred in Ecuador (2020). Finally, the unemployment rate (UNM) varied significantly across countries and years, with the lowest rate of 2.5% reported for Norway and Iceland (2007) and the highest rate of 27.5% recorded in Greece (2013). These substantial variations highlight the economic diversity across the sample countries and underscore the relevance of accounting for such heterogeneity in subsequent analyses.

Table 3. Descriptive Statistics

Variable	Observations	Mean	Min	Max	Std. dev.
FB	252	0.09	-17.85	28.57	6.00
CPV	252	0.02	0.0002	0.14	0.03
INF	252	1.24	-1.83	4.71	0.89
UNM	252	8.08	2.5	27.5	4.21

Source: *Research findings*

we compute a correlation matrix for all our variables to understand the relationship and direction between them. Table 4 demonstrates the relationship between the variables. It shows that there is a negative relationship between commodity price volatility and fiscal balance.

Table 4. Correlation Matrix of Variables

	FB	CPV	LINF	UNM
FB	1.00			
CPV	-0.16	1.00		
INF	-0.12	0.13	1.00	
UNM	-0.17	-0.07	0.05	1.00

Source: *Research findings*

When examining the long-run relationship between the variables, it is crucial to determine whether there is any cross-sectional dependence (Nyeadi, 2023). Therefore, we start by applying Pesaran's CD test. The values from the CD test imply that there is cross-sectional dependency among variables across all countries. Consequently, it is better to use Pesaran's CIPS unit root test for reliable results.

Table 5. Results of Cross-Sectional Dependence Test

Variable	CD-test	p-value	Mean p	Mean abs(p)
FB	17.51	0.000	0.43	0.51
CPV	10.78	0.000	0.27	0.45
INF	7.69	0.000	0.19	0.26
UNM	11.81	0.000	0.29	0.35

Source: *Research findings*

We analyzed the integration levels of the variables using CIPS, a method that considers cross-sectional dependence. Based on the results of unit root tests in Table 6, all variables are stationary at level or by one difference. Thus, we employ a panel cointegration test to examine whether there is a long-run relationship between the variables. The Westerlund test shows the panel is cointegrated since the hypothesis of no integration is rejected at a 10% level of significance. Therefore, it confirms the existence of a long-run relationship between the variables.

Table 6. CIPS Unit Root Test

	CIPS	Levels
FB	-1.97	I(1)
CPV	-2.65	I(0)
INF	-2.74	I(0)
UNM	-3.18	I(0)

Source: *Research findings*

Table 7. Results of Westerlund (2007) Panel Cointegration Test. Including trend

	Statistic	p-value
Variance ratio	1.61	0.054

Source: *Research findings*

We applied the PMG model in this research to capture both long-run and short-run effects. The error correction coefficient was found to be significantly negative, pointing to the existence of a long-run cointegrating relationship between variables. The empirical finding that commodity price volatility negatively affects fiscal balance, particularly in the short run, is theoretically robust and supported by multiple transmission mechanisms outlined in the existing literature. Commodity-exporting countries—especially those with limited economic diversification—experience pronounced fiscal sensitivities to fluctuations in global commodity markets. These sensitivities operate through both revenue and expenditure channels, which in turn influence the government's budgetary position. This aligns with Majumder et al. (2022), Alley (2016), and Samake & Spatafora (2012), who also found that increased volatility leads to fiscal balance deterioration. Majumder et al. (2022), for example, found that a one-unit increase in the standard deviation of commodity price volatility reduces fiscal balance by 0.04 units. This finding suggests that unanticipated fluctuations in commodity prices introduce substantial fiscal uncertainty, particularly in economies where a significant portion of government revenues is tied to the export of natural resources. When commodity prices become volatile, fiscal planning becomes increasingly difficult, often leading to overestimated revenue projections and subsequent budget deficits. This mismatch between expected and actual revenues—combined with the rigidity of public expenditures—contributes

to a deterioration of the fiscal balance. Furthermore, Spatafora & Samake (2012) also showed that with increasing commodity export prices, fiscal balance improves in the full sample (116 countries, including low- and middle-income countries), but in the panel of low-income commodity exporters, the fiscal balance deteriorates by 0.22 percentage points of GDP on average, suggesting that expenditures rises faster than revenues, Pointing to the presence of pro-cyclical[1] fiscal policies in these countries. Most commodity-dependent governments are unable to swiftly adjust their expenditure structures in response to revenue shortfalls. Politically sensitive components such as energy subsidies, public sector wages, and social spending are rarely reduced in the short term. As a result, during periods of volatility-induced revenue compression, governments resort to borrowing or drawdowns from reserves (if available), further stressing public finances. This short-term misalignment between income and expenditure dynamics reinforces procyclical fiscal behavior and erodes fiscal stability. The findings from Guérineau & Ehrhart (2011) indicate that commodity export price volatility affects direct taxes (income tax and non-tax revenues), suggesting that volatile prices for exported commodities negatively impact revenues. Hacime (2024) also mentioned that Fiscal dependance on fluctuating revenues leads to macroeconomic and fiscal vulnerability, which constrains the optimal conduct of public policies in commodity-exporting countries. This, in turn, affects the sustainability and effectiveness of their development. The author also examined the impact of commodity price volatility on public expenditure efficiency. The results show that there is a negative and significant relationship between these two variables, indicating that a 1% increase in commodity price volatility leads to a 0.015 point decrease in public expenditure efficiency. In contrast, the long-run relationship between commodity price volatility and fiscal balance, with a coefficient of +0.27, indicates an eventual adjustment process. Based on the estimated long-term coefficient of the model (+0.27), it can be concluded that a sustained 10% increase in commodity price volatility leads to a 2.7% increase in the financial balance relative to GDP. Over time, governments appear to adopt institutional or policy adaptations that mitigate the destabilizing effects of volatility. These adjustments may include the establishment of stabilization funds, improved forecasting methods, adoption of fiscal rules, or gradual expenditure re-alignment with more conservative revenue baselines. The positive long-run coefficient suggests that once fiscal policy becomes more forward-looking and countercyclical tools are put in place, countries can absorb volatility more effectively and even improve their fiscal standing. Similarly, Alley (2016) found a positive long-term effect in a study investigating how oil price volatility impacts the fiscal balance of oil-exporting countries. This outcome implies that in the sample countries, governments managed their expenditures in accordance with revenue constraints, leading to improved fiscal outcomes over the long run.

[1] Meaning that in recession periods, governments reduce spending and increase taxes, on the other hand, they increase spending and cut taxes in expansion times.

The results show that inflation has a positive and significant effect on fiscal balance in short-run. This positive relationship aligns with the theoretical framework, particularly the Patinkin effect. According to this theory, fiscal balances improve because revenues generally track nominal GDP, while expenditures tend to remain stable in nominal terms during the initial quarters, driven by primary expenditures. Zeng (2014) also found a positive and significant impact using the OLS model. Moreover, based on Garcia-Macia (2023), a 1% initial increase in inflation improves the overall and primary balance by about 0.5% of GDP in countries. Additionally, as inflation rises, the debt-to-GDP ratio tends to fall, leading to a slight improvement in fiscal balance in the medium term.

Abiad & Ostry (2005) also used inflation as an explanatory control variable in their model. Their results showed that the primary surplus response to inflation was positive and significant. They explained in addition to the Patinkin effect, higher inflation, which is associated with greater price volatility and higher real interest rates, forces fiscal effort to safeguard debt sustainability. In contrast, the long-run impact shows a negative relationship between inflation and fiscal balance. This negative sign may be due to the macroeconomic and stabilization policies undertaken by governments, which increase expenditures. An Increase in public spending directed toward social support to mitigate negative effects will adversely affect the fiscal balance (Alhendawya et al.,2023). Similarly, Kumar et al. (2007) also found a negative relationship between fiscal balance and inflation in OECD countries.

Unemployment has a negative and significant effect on fiscal balance in both the short and long run. The long-run results are consistent with the work of Behanzin & Mamadou (2021), who concluded that unemployment deteriorates the fiscal balance by about 0.014 points in the long-run. The results are also in line with the findings of Adedoyin et al. (2017), who applied a fixed-effect model and found a negative and significant effect of unemployment on fiscal balance. Additionally, they used the GMM model in their research, where the unemployment coefficient was insignificant in the short run. This is consistent with the results of this study, where the unemployment coefficient is insignificant in the short-run, though the coefficient has a lower value.

In a study by Dinca et al. (2016) that analyzed the evolution of fiscal balance, unemployment was included as an explanatory variable. The results showed a negative and significant relationship between unemployment and fiscal balance in their sample, which consisted of both developed and emerging countries. As discussed by Bénétrix & Lane (2010), Rising unemployment rates are linked to a reduction in the income ratio, while simultaneously contributing to an increase in the expenditure ratio. Their study also demonstrated that a decline in hours worked is linked to a further deterioration of the fiscal balance. Maltritz & Wüste (2015) similarly found that the unemployment rate has a significant and negative effect on fiscal balance, indicating that governments tend to run larger deficits when unemployment rates are higher.

To account for the impact of the 2008 global financial crisis, a dummy variable was introduced, taking the value of 1 for the pre-crisis period and 0 for the post-crisis period. The inclusion of this dummy variable did not lead to any significant changes in the long-run relationship between commodity price volatility and the fiscal balance, indicating that the structural impact of commodity volatility on fiscal outcomes remained stable across the crisis. However, in the short run, the PMG model revealed a statistically significant effect, suggesting that the crisis introduced temporary disturbances in the responsiveness of the fiscal balance to commodity price shocks. Notably, the dummy variable itself was not statistically significant in the long-run equation, implying that the underlying long-term dynamics were unaffected by the crisis episode. This contrast highlights the transitory nature of the crisis's influence, primarily altering short-term adjustments rather than long-run equilibrium relationships.

Table 8. Results of PMG Model Estimation

Dependent Variable: Fiscal Balance		Model 1 without dummy variable		Model 2 with dummy variable	
		Coefficient	P>|Z|	Coefficient	P>|Z|
Long-run	CPV	0.27	0.07	0.28	0.00
	INF	-0.78	0.00	-0.20	0.00
	UNM	-1.51	0.00	-0.81	0.00
	Dum2009			-0.27	0.49
Short-run	ECT	-0.17	0.00	-0.47	0.00
	ΔCPV	-0.12	0.03	-0.21	0.00
	ΔINF	0.22	0.00	0.15	0.00
	ΔUNM	-0.06	0.2	0.04	0.53
	Dum2009			-0.41	0.01
	cons	-0.08	0.00	0.36	0.01
Hausman test		1.56 (p = 0.67)			

Source: *Research findings*

A Hausman test was conducted to compare the Pooled Mean Group (PMG) and Mean Group (MG) estimators. The test yielded a non-significant statistic ($\chi^2 = 0.67$), indicating that the null hypothesis of long-run parameter homogeneity cannot be rejected. This result validates the use of the PMG estimator, confirming that the assumption of common long-run coefficients

across panel units holds empirically. Consequently, the PMG model is not only theoretically consistent with the nature of the data but also statistically more efficient, thereby serving as a reliable basis for interpreting the long-run relationships in the panel framework.

To address the heterogeneity in commodity-exporting structures, we divided countries into two main panels -energy-exporters and non-energy exporters- and estimated separate PMG models for each group. The results reveal that price volatility has a significantly stronger adverse impact on fiscal balances within energy-exporting nations, underscoring the heightened sensitivity of these economies to commodity fluctuations. This stratified analysis not only enriches our empirical contribution but also reinforces the study's assertion regarding composite commodity exporters.

Table 9. Results of PMG Model Estimation for Fuel Commodity Exporting countries

Energy dependent commodity exporter countries	Variable	Coefficient
Long-run	CPV	0.21
	INF	0.02
	UNM	-1.88*
	ECT	-0.26*
Short-run	ΔCPV	-0.15*
	ΔINF	0.14
	ΔUNM	0.06
	cons	-0.28*

Source: *Research findings*
*Note that: The prob values *,** and *** show statistical significance at 1%, 5% and 10% levels, respectively.*

Table 10. Results of PMG Model Estimation for Non-Fuel Commodity Exporting countries

Non-Energy dependent commodity exporter countries	Variable	Coefficient
Long-run	CPV	-0.02
	INF	-1.46*
	UNM	-2.02*
	ECT	-0.10*
Short-run	ΔCPV	-0.07
	ΔINF	0.21*
	ΔUNM	-0.09
	cons	-0.10*

Source: *Research findings*
*Note that: The prob values *,** and *** show statistical significance at 1%, 5% and 10% levels, respectively.*

To assess the robustness of the long-run relationships obtained from the Pooled Mean Group (PMG) estimator, we complement our analysis with a Panel

Vector Error Correction Model (P-VECM). This model offers a theoretically sound and statistically appropriate framework to evaluate the stability of long-run coefficients while simultaneously capturing short-run dynamics.

The decision to estimate a P-VECM is grounded in two essential econometric considerations. First, unit root tests revealed that the variables exhibit mixed integration orders, with some variables stationary at levels I (0) and others only after first differencing I (1). In such circumstances, conventional causality tests based on VAR models in levels or differences are not valid, as they assume homogeneity in the order of integration. Second, panel cointegration tests confirm the existence of a stable long-run relationship among the variables. These two conditions necessitate the use of an error correction framework that preserves long-run equilibrium information while allowing for valid short-run inference.

The results are presented in Table 11. the error correction term (ECT) in the equation for Δ(FB) is negative and statistically significant (coefficient = -0.249, $p < 0.01$), indicating that deviations from the long-run equilibrium are corrected over time. This confirms the presence of a long-run causal relationship from Commodity price volatility to Fiscal balance. Conversely, the ECT is statistically insignificant in the second equation, suggesting that there is no long-run causality from Fiscal balance to Commodity price volatility. In addition to the long-run relationship, the short-run dynamics were explored. Several short-run coefficients were found to be statistically significant. To assess the joint significance of short-run dynamics, Wald tests were conducted. Wald tests confirm causality from both Commodity price volatility to Fiscal balance and also from Fiscal balance to Commodity price volatility in the short-run.

These results jointly confirm that not only does a long-run cointegration relationship exist among the variables, but also that the adjustment process toward equilibrium is active and statistically meaningful in the short run. The use of Panel VECM thus strengthens and complements the findings from the PMG model, offering a more nuanced depiction of both equilibrium and dynamics across panel units.

Table 11. Results of Panel VECM Model Estimation

	Error Coef.	D(FB)	D(CPV)
Long-run	ECT	-0.25 (0.038)*	0.25 (0.041)*
Short-run	D(FB(-1))	-0.19 (0.071)**	-0.25 (0.077)**
	D(FB(-2))	-0.15 (0.079)**	-0.33 (0.084)**
	D(FB(-3))	-0.06 (0.081)**	-0.11 (0.087)**
	D(FB(-4))	-0.07 (0.079)**	-0.07 (0.085)**
	D(CPV(-1))	-0.35 (0.094)**	0.19 (0.010)*

D(CPV(-2))	-0.12 (0.071)**	0.26 (0.076)**
D(CPV(-3))	-0.22 (0.068)**	-0.26 (0.073)**
D(CPV(-4))	-0.09 (0.072)**	0.11 (0.078)**

Source: *Research findings*
*Note that: The prob values * and ** show statistical significance at 5 and 10% levels, respectively.*
The lag length of 4 was determined as optimal according to the Akaike Information Criterion (AIC), consistent with system stability and model fit diagnostics.

5.Concludes

This study investigates the impact of commodity price volatility on the fiscal balance of mixed commodity-exporting countries during the period 2004-2021. Previous studies predominantly focused on oil price volatility as the main driver of economic fluctuations. However, other research examining the impact of commodity price volatility primarily used OLS or GMM models. In contrast, this study utilizes the PMG model, which allows for a more suitable and efficient examination of both long-run and short-run effects. Based on the findings, commodity price volatilities have a negative and significant effect on fiscal balance in short-run. This suggests that commodity-exporting countries face a significant risk due to price volatilities. The divergence between predicted revenues and actual outcomes leads to fiscal deficits, and in developing countries, less efficient institutions may exacerbate macroeconomic instability, increasing government expenditures through social support programs as aimed at controlling unemployment, inflation, and stabilizing welfare levels. However, the sign becomes positive and statistically significant in the long run, implying that the adoption of forward-looking fiscal strategies[1] and countercyclical policy frameworks has enhanced governments' ability to cushion the adverse effects of external shocks. In addition to the direct effects of volatility, the study highlights the critical role of macroeconomic variables. Inflation was found to have a dual effect—positively influencing fiscal balance in the short term, but exhibiting a deteriorating effect in the long term, likely due to policy responses and increased public spending. Unemployment, on the other hand, consistently reduced fiscal balance over time, reinforcing the importance of labor market stability in supporting fiscal sustainability. To ensure the robustness and validity of the long-run relationships estimated through the PMG model, we conducted a Hausman test to evaluate the appropriateness of pooling long-run coefficients across panel units. The test statistic fails to reject the null hypothesis, thereby supporting the PMG estimator over the Mean Group (MG) alternative and justifying the assumption of long-run homogeneity. As an additional robustness check, we estimated a Panel Vector Error Correction Model (P-VECM), which allows for

[1] Forward-looking fiscal frameworks include tools like fiscal rules, stabilization funds, hedging instruments, and counter-cyclical spending strategies that help governments smooth out budget fluctuations over time.

the joint modeling of both short-run dynamics and long-run equilibrium relationships. The results of the P-VECM confirm the key findings of the PMG estimation. The results confirm the existence of a long-run equilibrium relationship running from Commodity price volatility to Fiscal balance, while no long-run causality is observed in the reverse direction. In the short run, however, the analysis reveals bi-directional causality, suggesting mutual responsiveness between the variables. These findings reinforce the robustness and stability of the relationships identified by the PMG estimation.

Ultimately, while commodity revenues will continue to play a central role in the budgets of many developing economies, this study highlights the need for structural reforms that prioritize fiscal resilience.

Strengthening fiscal resilience in commodity-exporting economies requires adopting forward-looking frameworks. Based on our empirical findings, countries that are able to save during boom periods and apply fiscal rules—such as Chile's structural balance rule or Norway's sovereign wealth fund—are better positioned to buffer against future price shocks.

Future research could further investigate the mediating role of governance quality and institutional strength in shaping fiscal responses to commodity shocks, or explore disaggregated effects across different commodity types and regional groupings.

6. Policy implications

The recurring terms of economic diversification and reducing reliance on government revenue from commodity exports, as demonstrated in this study and others (Benramdane, 2017; Abdel-Latif et al.,2018; Mukhtarov et al., 2020; Yating et al., 2022), highlights its importance. The impact of commodity price volatility effects the core decision-making element of fiscal policies, referred to as the Primary Fiscal Balance. Thus, implementing a sustainable and structured framework can help governments prepare for economic booms and busts (Marioli et al.,2024). Fiscal rules, which are laws designed to constrain fiscal policy (Grembi et al.,2016), are crucial in this regard. It is well-documented that the introduction of fiscal rules correlates with better fiscal performance (Caselli & Reynaud, 2020). Kopits & Symansky (1998) stated that fiscal rules contribute to macroeconomic stability, long-term sustainability, the reduction of negative spillovers, and overall policy credibility. Although discretionary policies may be theoretically superior, well-designed fiscal policy rules can offer a second-best solution to counter political pressures on fiscal policymaking.

A study by Luechinger & Schaltegger (2013) revealed that implementing fiscal rule can lower the probability of a projected deficit by about 28%. Moreover, fiscal rules enhance the transparency of the budgeting process. As Schick (2003) noted, without fiscal rules, governments and especially interest groups tend to increase spending. Government leaders often highlight rising expenditures as evidence of their positive contributions. Furthermore, as El Anshasy & Katsaiti (2013) proposed, the negative effects of natural resources are

more prevalent in countries with weak democratic and governance institutions. Therefore, Improving the structure of public spending and implementing well-targeted programs to support infrastructure and human development are essential to diversifying the economies of commodity-dependent countries.

High-income commodity-exporting countries such as Norway and Australia have demonstrated greater resilience to revenue volatility by employing a range of fiscal instruments, including sovereign wealth funds, hedging mechanisms, and countercyclical fiscal rules. For example, Norway's Government Pension Fund Global—one of the largest sovereign wealth funds in the world, with assets exceeding USD 1.5 trillion—serves as a key stabilizing mechanism, enabling the country to smooth expenditure across commodity cycles. In contrast, lower-income exporters such as Iran and Ecuador face more severe constraints and are in greater need of diversifying their economic base, strengthening domestic revenue mobilization, and reducing dependency on raw commodity exports.

Chile presents a compelling case of institutional innovation, having implemented a structural balance rule since 2001 that adjusts budgetary targets based on long-term copper prices and potential output. This approach has significantly mitigated the procyclicality of fiscal policy and improved budgetary stability. Taken together, these cases underscore the importance of designing country-specific fiscal frameworks that are sensitive to institutional capacity and commodity exposure. Such tailored strategies play a critical role in reducing vulnerability to external shocks and enhancing long-term fiscal sustainability. Additionally, risk management methods such as options and future contracts offer flexible opportunities to manage uncertainty over time, as discussed by Gaudenzi et al. (2021). Zhang et al., (2015) also noted that market-based commodity price risk management instruments allow commodity-producing countries to transfer their risks to others and improve earnings forecasts in the short-run.

While the primary focus of this study has been on the impact of commodity price volatility, inflation, and unemployment on fiscal balance, future research could benefit from incorporating macro-institutional variables to provide a more comprehensive understanding of fiscal dynamics. Variables such as institutional quality and the governance mechanisms of sovereign wealth funds play a critical role in shaping fiscal behavior, particularly in commodity-exporting economies. Due to data limitations—specifically, the lack of an integrated panel dataset covering all countries—these variables were not included in the present analysis. Nonetheless, given the multifaceted nature of the topic, future studies may adopt a regional approach or focus on countries with richer data availability to more precisely investigate the mediating or moderating roles of these variables, as well as the potential asymmetries in the effects of price fluctuations.

Author Contributions

Conceptualization, all authors; methodology, all authors; validation, all authors; formal analysis, all authors; resources, all authors; writing—original draft preparation, all authors; writing—review and editing, all authors; supervision, all authors. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest

The authors declare no conflict of interest.

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Appendices

Table 1. Results of Two-Step GGM Model Estimation for Commodity Exporting countries

Dependent Variable: Fiscal Balance

Variable	Coefficient	Std.err
L.FB	0.51*	0.16
CPV	-0.05	0.07
UNM	-0.27*	0.05
INF	0.12*	0.04
cons_	-0.1	0.22
Ar(1): 0.009	Ar(2): 0.82	Sargan : 1.00

Source: *Research findings*
*Note that: The prob values * and ** and *** show statistical significance at 1%, 5% and 10% levels, respectively.*