Received: 7 May 2021 | Revised: 12 January 2023 | Accepted: 6 April 2023

DOI: 10.1002/ijfe.2821

RESEARCH ARTICLE

WILEY

The predictive power of commodity prices for future economic growth: Evaluating the role of economic development

Martin Enilov[1,2]

[1]Department of Banking and Finance, Southampton Business School, University of Southampton, Southampton, UK

[2]School of Economics and Finance, Queen Mary University of London, London, UK

Correspondence
Martin Enilov, Department of Banking and Finance, Southampton Business School, University of Southampton, Building 2, 12 University Rd, Highfield, Southampton SO17 1BJ, UK.
Email: m.p.enilov@soton.ac.uk

Abstract

This paper investigates the extent to which commodity prices can predict economic growth, the growth exposure of the countries to specific commodity group, and whether the country stage of development matters for growth dependency on commodities. We use a novel time-varying mixed-frequency vector autoregressive model to jointly estimate causality between monthly commodity prices and quarterly economic growth for the period from January 1980 to March 2020. Our findings suggest that growth dependency on commodities varies over time and across different synthetic measures, but in general solid evidence of predictability is determined. The overall commodity index shows better performance in predicting economic growth than the segregated proxies of either fuel or non-fuel commodities in developed economies. However, the overall commodity index is as effective as the fuel index in predicting economic growth for their developing counterparts. We develop a new index of global commodity growth connectivity (GCGCI) to determine the economic growth dependency on commodities over time. Our results show that economic growth dependency on commodities has increased at least three times with financialization of commodity markets. The GCGCI for all commodities reveals a higher growth dependency on commodities in developing countries than developed ones in the post-financialization period. Interestingly, we find that growth decreases its reliance on fuel commodities in both developed and developing countries after financialization of commodity markets. Our findings bear implications for policymakers to design stabilization policies in an attempt to protect economies vulnerable to commodity price shocks and lay the foundation for sustainable economic growth.

KEYWORDS

commodity prices, commodity-growth index, economic growth, mixed-frequency VAR, predictability

1 | INTRODUCTION

Commodity prices are forward-looking economic variables, which make them a potentially powerful predictor for future economic growth (Garner, 1989; Stock & Watson, 2003). In conjunction with the evolution of contemporary financial markets and, particularly, the financialization of commodity markets (Basak & Pavlova, 2016), commodity markets have greatly increased their importance as an indicator for economic activity (see, among others, Deaton & Miller, 1995; Deaton, 1999; Dehn, 2000; Bleaney & Greenaway, 2001; Blattman et al., 2007; Collier & Goderis, 2008; Frankel, 2010; Collier & Goderis, 2012; Cavalcanti et al., 2015; Addison et al., 2016; Harvey et al., 2017; Mohaddes & Raissi, 2017; Balcilar & Bekun, 2020a, 2020b; Ge & Tang, 2020; Alexeev and Chin, 2021; Gokmenoglu et al., 2021; Gao et al., 2022; Li, 2023). Although numerous studies have been investigating the commodity-growth relationship, past studies have largely focused on the magnitude of this relationship, not much is known on whether or not commodity prices predict economic growth (see, Narayan et al., 2014, for discussion).

As the global economic uncertainty has increased gradually over the past years stipulated initially by the COVID-19 pandemic and the subsequent Russia–Ukraine conflict, knowledge on the predictive power of commodities for future economic growth is vivid for policymakers who use forecasts to project the consequences of particular policy decisions for certain policy targets. The aim of this study is to investigate and determine the growth dependency of the commodities and whether commodity prices can act as a predictor for future economic growth.

Unprecedently, the globalization has slightly but steadily boost the dependency of countries on commodities with more than half of the countries around the world being classified as commodity dependent as of 2019.[1] Yet, it is important to note that percentagewise, only a tenth of the developed countries are found to be commodity-dependent, as of 2019, compared to two-thirds of the developing economies (UNCTAD, 2021). Hence, developing economies are more prone to changes in commodity prices (see, Eberhardt & Presbitero, 2021), but also are some of their developed counterparts. Unfortunately, the forecasting commodity-growth literature has mostly focused on the United States economy (see, Alexeev and Chin, 2021; Gao et al., 2022), while little is known on whether or not commodity prices predict economic growth for developing economies (Narayan et al., 2014). In light of this research gap, our study examines the predictive power of commodity prices for future economic growth in 18 commodity-dependent countries, among them 10 are developing and the balance is developed countries.

This paper simultaneously contributes to the existing literature in the following ways. First, most academic work in the forecasting commodity-growth literature has been focused on developed economies and particularly on the United States. In this paper, we consider a broader set of commodity-dependent economies, both developing and developed, that are usually ignored in the forecasting literature, and then empirically examine their growth dependency on commodity prices.

Second, a large body of the existing literature is devoted to study the impact of oil prices on economic growth (for example, Narayan et al., 2014; Sharma et al., 2019; Wang & Liao, 2022), however, not all commodity-dependent countries are reliant on oil (see, Deaton & Miller, 1995; Cashin et al., 2004, for discussion). During the last 20 years, the proportion of energy-dependent countries remain almost unchanged of about a third of all commodity-dependent economies, whereas the percentage of mineral-dependent countries doubled to a third and, last but not least, the proportion of economies dependent on agricultural commodities declines by almost a quarter to slightly above thirty percent of all commodity-dependent countries (UNCTAD, 2021). As can be determined, the commodity-dependent economies are not all dependent on a single commodity, such as oil, but also on non-fuel commodities. Unfortunately, the non-fuel commodity literature is scarce and not much is known on whether or not the prices of non-fuel commodities predict economic growth. In the view of the above research gaps, our paper investigates the extent to which commodity prices can predict economic growth, the growth exposure of the countries to specific commodity group, and whether the country stage of development matters for growth dependency on commodities.

Third, our study contributes to the scarce but rapidly growing body of work on modelling economic growth in a mixed-frequency context (see, Baumeister & Guérin, 2021; Clements & Galvão, 2008; Enilov & Wang, 2022; Ferrara & Marsilli, 2019; Liu & Song, 2018). The advantage of this mixed-frequency approach is in its explicit dealing with the issue of temporal aggregation. This statistical bias is commonly ignored in past studies. But temporal aggregation leads to loss of information, due to the smaller number of observations available (Marcellino, 1999), and its negligence may draw false inferences in terms of finite-sample power of the testing procedure. Unfortunately, the existing data on Gross Domestic Product (GDP) per capita, commonly used in the calculation of economic growth, has mainly been available in either quarterly or annual time frequency, especially, for developing economies, which mandate the earlier works in the commodity-growth literature to aggregate the monthly or even higher-frequency commodity price data into a lower-frequency, such as annual (see, Cavalcanti et al., 2015; Collier & Goderis, 2012; Mohaddes & Raissi, 2017; Pradhan et al., 2015) or quarterly (see, Dehn, 2000; Gao et al., 2022; Ge & Tang, 2020; Narayan et al., 2014). Such data aggregation was necessary to match the frequency of the GDP data and to meet the requirements of the standard empirical models that all data has to be at the same frequency. However, the aggregation of monthly commodity data into a lower-frequency, such as quarterly, leads to loss of information in the empirical models (Adams et al., 1979; Garner, 1989), and is highly likely to omit useful information about the forecasting ability of the commodity variables on economic growth, as two-thirds of the commodity prices are already known but those data are lost during the aggregation process. To deal with the problem of temporal aggregation, our paper adopts the mixed-frequency vector autoregressive (MF-VAR) approach of Ghysels et al. (2016) that allows us to estimate monthly commodity prices and quarterly economic growth variables within the same empirical model and, hence, overcomes the aggregation bias, as discussed by Götz et al. (2016). To ensure the robustness of our results, we undertake long-horizon predictability analysis considering four different forecasting horizons: $h=2$, $h=3$, $h=4$, and $h=6$. By doing so, we address the concern in the commodity-growth literature that commodity price predictability may vary with the forecast horizon (Gargano & Timmermann, 2014). As such, we are among the first to incorporate joint estimation of monthly commodity prices and quarterly economic growth variables in the commodity-growth literature.

Fourth, our paper speaks directly to the time-varying forecasting literature. Hansen (1992) and Lin and Teräsvirta (1994) highlight that parameter non-constancy may have adverse impact on statistical inference. Lee and Chang (2005) claim that the test statistics are biased towards non-rejection of the null hypothesis in the presence of structural breaks. In the existing literature, several studies have identified the presence structural breaks in the commodity-growth relationship (Baumeister & Peersman, 2013; Cavalcanti et al., 2015; Cross & Nguyen, 2017; Cuñado & De Gracia, 2003, 2005; Hamilton, 1996, 2003; Hooker, 2002). Narayan et al. (2014) point out that the commodity-growth relationship is not stable over time and, therefore, the standard linear models may fail to detect predictability. But the literature concerning the time variation nature of commodity-growth relationship is still scarce and not yet implicitly explored, especially, for developing economies. In that vein, we extend the mixed-frequency approach of Ghysels et al. (2016) to a time-varying setting to control for parameter instability. To further reinforce our results, we construct a new index of Global Commodity Growth Connectivity (GCGCI) to determine the growth dependency on commodities over time in the following three instances: all countries, developing and developed economies. By doing so, this paper complements the forecasting literature by determining the time variation behaviour of commodity prices in forecasting economic growth.

The rest of the paper is organized as follows. In the next section we provide a brief theoretical background and survey of the relevant literature. Section 3 presents the econometric methodology. Data information and preliminary statistics are provided in Section 4. Section 5 discusses the empirical results. The robustness check is provided in Section 6. Section 7 concludes the paper.

2 | BACKGROUND AND PRIOR LITERATURE

Numerous theories have been developed to describe the commodity-growth relationship. One of them is the commodity wealth channel by means of which commodity prices can affect the real economy as proposed by Ferraro and Peretto (2018). More precisely, any changes in the commodity prices have a direct impact on the amount of goods and services produced in the economy (Alexeev & Chih, 2021; Balcilar & Bekun, 2020b; Brückner & Ciccone, 2010; Cuñado & De Gracia, 2003, 2005; Hamilton, 1996, 2003; Kilian, 2009; Narayan et al., 2014; Tahar et al., 2021). On one side, an increase in the commodity prices results in lower discretionary income of households own to changes in retail prices, as a result of high production costs, but also due to an increase in the prices of primary commodities in international markets (Edelstein & Kilian, 2009). As a consequence, the amount of money that households have available for spending and saving is reduced, which naturally leads to a decline in consumption and, therefore, growth in the economy tends to slow down (Svensson, 2005). In that way, commodity prices directly affect household income by changing the value of commodity endowment and, therefore, inducing wealth effect (Ferraro & Peretto, 2018). On the other side, a decrease in the commodity prices tends to lower the production costs and increase the households' consumption as a consequence of more competitive retail prices on the market, which should result in higher GDP growth in the next period due to the higher consumption patterns (Mendoza, 1997). In a nutshell, commodity prices variability results in faster or slower growth depending on the degree of commodity endowment, but in either case it affects household welfare.

A myriad of studies have investigated the oil-growth relationship in the case of the US (see, among others, Hamilton, 1983, 1996; Hooker, 1996; Kilian, 2009; Berument et al., 2010; Cavalcanti et al., 2011; Narayan et al., 2014; Cavalcanti et al., 2015; Pradhan et al.; 2015; Gokmenoglu et al., 2016; Troster et al., 2018; Maheu et al., 2020; Alexeev and Chin, 2021; Gao et al., 2022). Hamilton (1983) concludes that escalations in oil prices are responsible for declines in the US Gross National Product, while Hamilton (1996) finds that oil prices Granger-cause the US GDP. Similarly, Hooker (1996) determines that oil prices Granger-cause the US GDP growth, but the causal link is varying over time. Kilian (2009) uses quarterly structural VAR model to determine that real GDP growth in the US responses to changes in the oil prices. In a likely manner, Maheu et al. (2020) conclude that oil price shocks impact GDP growth in the US. Troster et al. (2018) employ a Granger-causality in quantiles analysis for the US and find evidence of causality from oil prices to economic activity at the extreme quantiles of the distribution. Alexeev and Chin (2021) use yearly panel data for the US states to examine the impact of oil and gas price shocks on economic growth for the period 1975–2018. They find that price shocks have small but highly statistically significant effects on state economies. Gao et al. (2022) find that the option-implied oil price volatility is a strong negative predictor of economic growth in the US. While most of the literature has been focused on the US economy and, its link to the oil market, not much is known on oil-growth relationship outside of the US.

As noted, most of the past literature has focused on oil prices and their impact on the US economy. A seldom but growing literature investigates the existence of oil-growth relationship outside the US. For example, Berument et al. (2010) find that oil price increases have a statistically significant and positive effect on the economic growth for Algeria, Iran, Iraq, Kuwait, Libya, Oman, Qatar, Syria, and the United Arab Emirates, but no impact on growth in Bahrain, Djibouti, Egypt, Israel, Jordan, Morocco, and Tunisia. Cavalcanti et al. (2011) show that oil abundance has a positive effect on both long-run income levels and short-run economic growth covering the period 1980 to 2006 for a sample of 53 countries. Narayan et al. (2014) employ quarterly data to test whether oil prices predict economic growth for a set of developed and developing countries. They find evidence of predictability for no less than two-thirds of all sample countries, with greater evidence of predictability for developed countries. Gokmenoglu et al. (2016) discover a long-run relationship among agricultural value added, economic growth, oil rent, and oil production, as well, a causal relationship running from oil rent, oil production, and agricultural value added to economic growth in Nigeria. In contrast, Pradhan et al. (2015) do not find evidence of causality between economic growth and oil prices for G-20 countries over the period from 1961 to 2012. Sharma et al. (2019) find that oil prices significantly predict growth rate of industrial production in Indonesia from 1986 to 2018. Adedoyin et al. (2020) determine that energy consumption affects economic growth in a set of 16 EU countries from 1997 to 2015. Agboola et al. (2021) denote the existence of a feedback relationship between energy consumption and economic growth in Saudi Arabia. Although the oil-growth literature has received extensive attention, its focus primarily remains within the scope of county-level or regional studies, little is known in a global context.

The literature has extensively explored the impact of energy commodities and, in particular oil, on economic growth. However, it has paid little attention to the other commodities and their role as a leading indicator for economic growth. Deaton (1999) use annual commodity-growth data to determine that economic growth in African economies remains heavily dependent on exports of primary commodities; as such, these economies do better when the prices of commodities are rising rather than when they are falling. Bleaney and Greenaway (2001) use annual data in a fixed effects panel setting to analyse the relationship between terms of trade and economic growth for 14 sub-Saharan Africa economies. The authors find that volatility in the terms of trade has a negative impact on growth, while growth depends positively on the current level of terms of trade and negatively on the lagged change. Raddatz (2007) uses aggregate commodity data in a panel VAR setting to examine the effect of commodity price shocks on economic growth for 40 low-income countries between 1965 and 1997. The author finds that commodity prices have a positive effect on GDP growth. Collier and Goderis (2008) argues that half of the current growth of Africa's commodity-exporting economies is attributable to the short-term effects of the commodity price boom.

In contrast, numerous studies find mixed results on the existence of commodity-growth relationship. For example, Deaton and Miller (1995) investigate the commodity-growth relationship in a standard VAR model for 32 sub-Saharan African countries from 1958 to 1992. They find evidence for a commodity-growth relationship only for the Central African Republic, Ghana, Liberia and Mauritania. Similarly, Dehn (2000) finds that per capita economic growth is significantly reduced by the negative commodity price shocks, while positive commodity price shocks have no lasting impact on economic growth for 113 countries from 1957Q1 to 1997Q4. Blattman et al. (2007) find no statistically significant relationship between the terms of trade growth and income growth in the commodity-specialized Periphery but the Core nations show evidence that income growth is positively correlated with the terms of trade growth between 1870 and 1939.[2] Likewise, Cavalcanti et al. (2015) examine the commodity-growth relationship between 1970 and 2007 considering annual data split into two sets: (a) 62 primary commodity exporters and (b) 56 other countries that have more diversified export basket. The authors find that the commodity terms of trade growth enhances real GDP per capita for the subsample of primary commodity exporters but not for nations with more diversified export basket. Addison et al. (2016) find weak evidence for the impact of agricultural commodity price shocks on economic growth in Sub-Saharan Africa countries. Ge and Tang (2020) aggregate daily commodity prices data into quarterly frequency to investigate the predictive power of commodity prices for future economic growth in G20 countries, but the EU and Saudi Arabia, from 1993Q1 to 2017Q1. They find that commodity returns significantly predict economic growth for about half of the sample countries. In the view of this, the commodity-growth relationship has been examined by a myriad of published research, however, the existence of causal relationship between commodity prices and economic growth is mixed, especially, for developing economies, and further investigation is needed.

To summarize, a large focus of the past literature has been given to oil prices but with the rapid financialization of commodity markets other commodities have gained in importance as potential predictors for future economic growth. Further to that, the existing commodity-growth literature mostly concentrated on county-level or regional studies, little is known in a global context. These studies have also provided mixed results on the relationship between commodity prices and economic growth. However, policymakers may establish strategies in favour of commodities that have a favourable effect on economic growth. Achieving this requires a comprehensive approach to commodity management embedded within a broad sustainable development strategy, careful management of resource revenues and firm policy commitments. Hence, testing the predictive power of commodity prices for future economic growth is worth investigating, and is what this paper does. The next section illustrates how we perform these tests.

3 | METHODOLOGY

This study adopts the MF-VAR model of Ghysels et al. (2016) to examine the relationship between monthly commodity prices (CP) and quarterly economic growth (EG). The MF-VAR is a suitable method for testing Granger causality due to being observation driven approach that directly relates to the standard VAR model (Ghysels, 2016). Since commodity prices are monthly time series, j stands for the jth month of quarter τ, where $j \in \{1,2,3\}$ and $\tau \in \{1,2...,T_L\}$ is a time sequence at quarterly frequency. The MF-VAR (p) model is specified as follows:

$$\underbrace{\begin{bmatrix} \Delta CP_{(\tau,1)} \\ \Delta CP_{(\tau,2)} \\ \Delta CP_{(\tau,3)} \\ EG_{(\tau)} \end{bmatrix}}_{\equiv X_{(\tau)}} = \sum_{k=1}^{p} \underbrace{\begin{bmatrix} a_{11,k} & a_{12,k} & a_{13,k} & a_{14,k} \\ a_{21,k} & a_{22,k} & a_{23,k} & a_{24,k} \\ a_{31,k} & a_{32,k} & a_{33,k} & a_{34,k} \\ a_{41,k} & a_{42,k} & a_{43,k} & a_{44,k} \end{bmatrix}}_{\equiv A_k} \underbrace{\begin{bmatrix} \Delta CP_{(\tau-k,1)} \\ \Delta CP_{(\tau-k,2)} \\ \Delta CP_{(\tau-k,3)} \\ EG_{(\tau-k)} \end{bmatrix}}_{\equiv X_{(\tau-k)}} + \underbrace{\begin{bmatrix} \varepsilon_{(\tau,1)} \\ \varepsilon_{(\tau,2)} \\ \varepsilon_{(\tau,3)} \\ \varepsilon_{(\tau,4)} \end{bmatrix}}_{\equiv \varepsilon_{(\tau)}}, \tag{1}$$

where $\Delta CP(\tau,j)$ is the annual log-differences of commodity prices; $EG(\tau)$ denotes economic growth at quarter τ; A_k is a coefficient square matrix for $k = 1,...,p$, where p is the lag length which is selected using the Bayesian information criterion (BIC); $\varepsilon_{(\tau)}$ is vector of residuals. The constant term is not included in Equation (1) in line with Ghysels et al. (2016).[3] Hence, Equation (1) can be written into the following MF-VAR (p,h) model:

$$X_{(\tau+h)} = \sum_{k=1}^{p} A_k^{(h)} X_{(\tau+1-k)} + u_{(\tau)}^{(h)}, \tag{2}$$

where h is the test horizon, $u_{(\tau)}^{(h)} = \sum_{k=0}^{h-1} \boldsymbol{\phi}_k \varepsilon_{(\tau-k)}$, $\boldsymbol{\phi}_k$ is a vector of coefficients. The following assumptions ensure the consistency and asymptotic normality of the least squares estimator $\widehat{A_k}$, in alignment with Ghysels et al. (2016). First, all roots of the polynomial lie outside the unit circle. This ensures that the MF-VAR is state stationary. Second, $\varepsilon_{(\tau)}$ is strictly stationary martingale difference sequence with finite second moment. Third, $\{X_{(\tau)}, \varepsilon_{(\tau)}\}$ obeys α-mixing process, which is a standard assumption to ensure the validity of bootstrapping for VAR models (see, Götz et al., 2016).

To perform Granger causality test, we compute the Wald statistics based, where $B(h) = \left[A_1^{(h)}, ..., A_p^{(h)}\right]'$ is a set of MF-VAR (p,h) coefficients. The Wald statistic can be written as follows:

$$W_{T_L^*}[H_0(h)] \equiv T_L^* \left(Rvec\left[\widehat{B}(h)\right] - r\right)' \times \left(R\widehat{\sum}_p(h)R'\right)^{-1} \times \left(Rvec\left[\widehat{B}(h)\right] - r\right) \tag{3}$$

where $T_L^* \equiv T_L - h + 1$ is the effective sample size of the MF-VAR (p, h); $\widehat{B}(h)$ is the least square estimator; $\boldsymbol{R}$ is a selection matrix of full row rank; $\boldsymbol{r}$ is a restricted vector. The null hypothesis of non-causality $H_0(h)$ is a linear restriction defined as:

$$H_0(h): \boldsymbol{R}vec[B(h)] = \boldsymbol{r}, \quad (4)$$

where $\boldsymbol{r}$ is a restricted vector of zero values; $W_{T_L^*}[H_0(h)] \rightarrow \chi_q^2$ under $H_0(h)$.

As previously discussed, the commodity-growth relationship is exposed to the presence of structural breaks. To overcome this issue, we extend the time-invariant MF-VAR (p,h) model to a time-varying framework using a rolling window approach. The rolling procedure requires no explicit assumption for the nature of time variation in the data (Chen et al., 2010) and adapts more quickly to a particular event compared to its recursive counterpart. The window size of 50 quarters is used for performing the rolling window analysis.

The commodity prices are known to be highly volatile (Deaton & Laroque, 1992), and often exhibit heteroskedasticity patterns (Liu & Tang, 2011). To account for heteroskedasticity, we adopt the recursive-design wild bootstrap by Gonçalves and Kilian (2004), which does not require knowledge on the true error distribution and is robust to unknown form of conditional heteroskedasticity.[4] The Wald statistic p-values, $\widehat{p_N}$, are computed based on the recursive-design wild bootstrap algorithm with $N = 999$ replications. The null hypothesis $H_0(h)$ is rejected at level α if $\widehat{p}_N \leq \alpha$.

Finally yet importantly, we develop a new index of Global Commodity Growth Connectivity (GCGCI) to determine the economic growth dependency on commodities over time. In other words, our index depicts the periods of strong and weak dependency of economic growth on commodity prices. The GCGCI is based on the results from the time-varying MF estimations at the horizon of one quarter. The index value is between 0 and 100. The high index values denote high dependency of growth on commodities, whereas the low values of the index determine low growth dependency on commodities. Following Billio et al. (2012), the GCGCI index is calculated by dividing the total number of *identified* causal links, GC_{t^*}, to the number of all possible causal links, N_{t^*}, for each rolling window, t^*, and then multiplied by 100. The causal link is specified as *identified* if the null hypothesis of non-causality is rejected at the 10% level of significance, considering each country case. The GCGCI is calculated using the following index formula:

$$GCGCI = \frac{GC_{t^*}}{N_{t^*}} \times 100 \quad (5)$$

Based on Equation (5), we construct the following *GCGCI* indexes: *GCGCI All Commodities*, *GCGCI Fuel*, and *GCGCI Non − fuel*. Precisely, *GCGCI All Commodities* is based on the results from CRB (BLS) Spot Price Index, *GCGCI Fuel* refers to the results from WTI prices, and *GCGCI Non − fuel* represents the results from IMF non-fuel commodity price index. Each of the above indexes is constructed in three instances, that is, for all countries as a whole, developing and developed economies.

4 | DATA AND PRELIMINARY STATISTICS

4.1 | Data

This study uses monthly world commodity prices from January 1980 to March 2020 and quarterly real GDP per capita from 1980:Q1 to 2020:Q1 for a set of 18 commodity-dependent countries. Of these 18 countries, 10 are developing and the balance is developed countries.[5] The sample size is dictated by data availability.[6] Following Gargano and Timmermann (2014), the world commodity prices are calculated in annual log-differenced form and are proxied by the CRB (BLS) Spot Price Index, obtained from Datastream. The use of changes in commodity prices is consistent with the previous works by Brückner and Ciccone (2010), Chen et al. (2014), Ferraro et al. (2015) and Ciccone (2018). Similarly, following Collier and Goderis (2012), the economic growth is calculated as annual log-differences of real GDP per capita; the real GDP per capita data are at a constant 2015 US dollars, downloaded from Datastream.

Due to the inclusion of energy-related products into the index basket of CRB (BLS) Spot Price Index, we use the IMF non-fuel price index to examine the role that *non-fuel commodities* play in forecasting economic growth. The index is downloaded from Global Financial Data for the period January 1980–June 2017 and then we manually extend it for the rest of investigation period. The latter is necessary due to discontinuity of the old IMF non-fuel price index and the new one being available only since January 1992. The extension of the IMF non-fuel price index is made in accordance with the guidelines provided in the technical note for IMF Primary Commodity Prices as of January 25, 2019 (IMF, 2019). Our extended index uses the commodity basket as of the old IMF non-fuel price index, for consistency reasons, while the index weights are calculated based on the global import share over a 3-year period (2014–2016). Example of past studies that use the IMF non-fuel price index are Chen and Rogoff (2003), Cashin et al. (2004), De Broeck and Sløk (2006) and Chen et al. (2010). Further, as a proxy for energy (fuel) prices we use world oil prices represented by the West

TABLE 1 Descriptive statistics

	Mean	Min	Max	Standard deviation	Skewness	Kurtosis	p-JB	Obs.
Economic growth								
Argentina	0.305	−18.925	14.041	6.315	−0.433	2.832	0.049	157
Australia	1.640	−4.834	6.804	1.814	−0.540	4.250	0.009	157
Belgium	1.446	−4.514	4.771	1.607	−0.884	5.147	0.001	157
Bulgaria	2.846	−18.311	25.362	6.487	−0.091	5.474	0.001	157
Canada	1.213	−5.246	5.072	2.201	−0.829	3.979	0.001	157
Chile	3.022	−15.217	12.719	4.205	−1.433	6.929	0.001	157
Denmark	1.509	−6.902	6.382	2.130	−0.936	5.452	0.001	157
Hong Kong	3.080	−10.442	14.873	4.265	−0.397	4.254	0.004	157
Indonesia	3.679	−21.562	14.241	4.091	−3.363	19.854	0.001	157
Malaysia	3.368	−14.348	10.754	3.758	−1.834	8.340	0.001	157
Netherlands	1.566	−4.956	4.868	1.959	−0.853	3.721	0.001	157
Norway	1.640	−3.301	7.898	2.196	0.222	2.882	0.322	157
Philippines	1.588	−13.985	8.519	3.803	−1.695	6.607	0.001	157
Portugal	1.526	−4.519	7.079	2.442	−0.198	2.712	0.326	157
Singapore	3.769	−11.601	15.322	4.116	−0.799	4.561	0.001	157
South Africa	0.222	−7.317	4.689	2.547	−0.583	2.943	0.003	157
South Korea	5.263	−8.465	14.275	3.662	−0.475	4.425	0.008	157
Thailand	3.896	−14.592	13.918	3.962	−1.219	7.106	0.001	157
Commodity prices								
All commodities								
CP(τ,1)	−0.429	−36.018	28.511	10.691	−0.473	3.848	0.014	157
CP(τ,2)	−0.491	−34.747	26.120	10.603	−0.537	3.679	0.014	157
CP(τ,3)	−0.536	−33.227	27.841	11.010	−0.569	3.993	0.006	157
Non-fuel commodities								
CP(τ,1)	−0.455	−28.509	31.175	10.193	−0.015	3.180	0.500	157
CP(τ,2)	−0.557	−28.645	25.580	10.077	−0.034	3.145	0.500	157
CP(τ,3)	−0.479	−31.037	25.824	10.372	−0.074	3.167	0.500	157
Fuel commodities								
CP(τ,1)	−0.286	−105.238	83.765	30.645	−0.513	4.146	0.006	157
CP(τ,2)	−0.373	−87.647	93.625	29.901	−0.336	4.051	0.015	157
CP(τ,3)	−0.747	−100.001	88.685	30.584	−0.425	4.113	0.009	157

Note: The table reports the descriptive statistics for economic growth and commodity prices. CP(τ,j) denotes commodity prices as defined in the methodology section. For instance, CP(τ,1) refers to the commodity prices at the first month of quarter τ. "p-JB" signifies the p-value of the Jarque-Bera test for normality.

Texas Intermediate (WTI) crude oil, which choice is in line with Borenstein et al. (1997), Kilian (2009), Kilian and Park (2009), Phan et al. (2015) and Gokmenoglu et al. (2021). The monthly WTI price data are denominated in US dollars and are obtained from Datastream.[7]

As a robustness check, we use alternative aggregate indexes of world commodity prices: Goldman Sachs Commodity Price Index (GSCI), Moody's (Moody's) and Thomson Reuters Core Commodity Equal Weighted Index (TR CCI) (see, Chen et al., 2010). All indexes are taken from Global Financial Data.

The nominal commodity price series are converted into real commodity prices by using the manufactures unit value (MUV) index, which is obtained from the UNCTAD database. The choice of deflator is consistent with the past studies of Grilli and Yang (1988) and Cashin et al. (2004).

4.2 | Descriptive statistics

Table 1 presents the descriptive statistics of the monthly commodity return series and the quarterly economic growth. Our results show positive mean values for the economic growth series in all countries. Specifically, developing economies are characterized by relatively higher averages compared to their developed counterparts, with the economic growth in South Korea ranked with the highest average followed by Thailand. The following result is consistent with Ge and Tang (2020) who discover that growth rates of economy in developing countries are higher compared to those in developed ones. Not surprisingly, the lowest volatility in economic growth is found in developed economies signified by the lowest standard deviation of 1.607 for Belgium, followed by 1.814 for Australia. This suggests that, over the sample period, the economic growth in those countries is less uncertain compared to their developing counterparts. The highly volatile economic development for developing nations is also determined by past studies of Cavalcanti et al. (2015) and Maheu et al. (2020). The results are also confirmed by the min-max spreads in Table 1. Considering commodity prices, we find that they exhibit negative averages regardless the commodity group. Besides, fuel commodities have the lowest returns but at the same time the highest volatility among all commodity groups. The highest price uncertainty of energy markets is not a surprise, but it usually determines periods of a crisis such as the 2007–2008 global financial crisis (GFC), the subsequent Syrian civil war, when oil prices are exposed to large fluctuations, as also discussed by Pan et al. (2017) and Balcilar and Bekun (2020a). Both kurtosis and skewness suggest that the data may be affected by non-normality. To confirm this, we use the Jarque-Bera test which results suggest rejection of the null hypothesis of normal distribution for almost all series at 10% level of significance. In other words, most series are likely to have non-normal distributions, which may lead to spurious estimates, as emphasized by Bekaert and Harvey (2002). However, the asymptotic theory of MF-VAR models does not require the normality assumption (Ghysels, 2016), which is another advantage of the model compared to standard causality tests.

Table 2 reports the correlation coefficients between the monthly commodity return series and the quarterly economic growth. Our results show mostly positive relationship between the variables, with few exemptions. In fact, only the economic growth for Bulgaria and Norway exhibit negative correlation with fuel and non-fuel commodities, respectively. Nonetheless, the correlation results are rather mixed and numerous coefficients suggest weak to moderate correlation. As the correlation coefficient does not tell us about the direction of causality, further investigation is needed.

4.3 | Unit root test

We examine the stationarity property of our series by employing three different unit root tests: augmented Dickey-Fuller (ADF) (Dickey & Fuller, 1979) and Phillips-Perron (PP) (Phillips & Perron, 1988), and Fourier augmented Dickey-Fuller (Fourier ADF) (Enders & Lee, 2012). Although the first two tests are standard unit root tests, the latter one allows for unknown number of level breaks so it suits the purpose of our study (Enders & Lee, 2012). The lag length is selected via the BIC with maximum lags of four for both ADF and Fourier ADF tests. For the PP test, the lag length is selected via Bartlett kernel with the Newey-West automatic bandwidth selection. The PP test is employed as per its robustness against unspecified autocorrelation and heteroscedasticity, which are common issues in commodity prices (Beck, 2001). The null hypothesis of a unit root against the alternative hypothesis of no unit root is specified for all three tests. All tests include only intercept, which is consistent with the economic theory. Table 3 shows the results from the three unit root tests suggesting that commodity prices and economic growth series are both unit root stationary at 10% level of significance.

4.4 | Structural instability

Commodity markets are occasionally exposed to massive booms and busts (Carter & Smith, 2011). Hence, assuming that the coefficient of commodity prices is stable would be too naïve (Cavalcanti et al., 2015; Cross & Nguyen, 2017; Cuñado & De Gracia, 2003, 2005; Hamilton, 2003; Hooker, 2002; Narayan et al., 2014; Tahar et al., 2021). We check for the existence of structural breaks in our models using Andrews' (1993) QLR test for parameter instability (Bekaert et al., 2013; Ben-Rephael et al., 2012; Chen et al., 2010; Rossi, 2005). The Andrews' (1993) QLR test has the advantage to determine parameter instability when the location of structural breaks is unknown. The null hypothesis of structural stability is specified against its alternative of a one-time structural break.[8] Table 4 reports the results from Andrews' (1993) QLR test that determine the existence of parameter instability for at least two-thirds of the sample countries regardless the commodity group considering 10% level of significance. The finding that commodity-growth relationship is heavily affected by structural breaks is consistent with the past studies of Cavalcanti

TABLE 2 Correlation analysis

	All commodities			**Non-fuel commodities**			**Fuel commodities**		
	CP(τ,1)	**CP(τ,2)**	**CP(τ,3)**	**CP(τ,1)**	**CP(τ,2)**	**CP(τ,3)**	**CP(τ,1)**	**CP(τ,2)**	**CP(τ,3)**
Argentina	0.210	0.251	0.229	0.300	0.298	0.278	0.075	0.079	0.063
Australia	0.205	0.173	0.129	0.089	0.047	0.058	0.088	0.089	0.128
Belgium	0.235	0.251	0.249	0.281	0.270	0.290	0.242	0.304	0.300
Bulgaria	0.159	0.114	0.080	0.143	0.106	0.075	−0.048	−0.084	−0.075
Canada	0.316	0.270	0.222	0.317	0.259	0.258	0.235	0.241	0.214
Chile	0.230	0.212	0.170	0.168	0.114	0.066	0.127	0.119	0.127
Denmark	0.132	0.124	0.117	0.246	0.247	0.247	0.112	0.104	0.072
Hong Kong	0.352	0.381	0.424	0.451	0.480	0.496	0.216	0.278	0.300
Indonesia	0.369	0.373	0.391	0.400	0.399	0.385	0.221	0.246	0.236
Malaysia	0.547	0.566	0.584	0.548	0.556	0.542	0.455	0.493	0.462
Netherlands	0.234	0.204	0.164	0.283	0.250	0.218	0.198	0.221	0.186
Norway	0.053	0.028	0.019	−0.026	−0.035	−0.051	0.021	0.018	0.004
Philippines	0.149	0.171	0.195	0.233	0.259	0.259	0.130	0.156	0.170
Portugal	0.053	0.054	0.056	0.053	0.049	0.046	0.114	0.125	0.158
Singapore	0.503	0.558	0.577	0.564	0.587	0.600	0.368	0.415	0.412
South Africa	0.518	0.477	0.427	0.483	0.431	0.382	0.351	0.361	0.346
South Korea	0.150	0.192	0.244	0.269	0.307	0.337	0.168	0.230	0.262
Thailand	0.278	0.289	0.329	0.333	0.365	0.380	0.247	0.268	0.287

Note: The table reports the correlation coefficient between the commodity prices and economic growth for the given country. CP(τ,j) denotes commodity prices as defined in the methodology section. For instance, CP(τ,1) refers to the commodity prices at the first month of quarter τ.

et al. (2015) and Tahar et al. (2021). Alongside, our results reveal that the dates of structural breaks differ among the sample countries, see Table 4. On one hand, the break dates at commodity-growth relationship for many Asian developing economies are determined in the mid-1990s. This coincides with the period of large upsurge in the foreign debt-to-GDP ratios for most of them, which was a major prerequisite for the onset of the 1997 Asian financial crisis. Therefore, our findings add to the study of Li (2023) that the 1997 Asian financial crisis has impact on the commodity-growth relationship not only for China but also for other Asian economies, especially, those located at Southeast Asia. On the other hand, our results show that the break dates at commodity-growth relationship for numerous European economies overlap with the onset and the subsequent spread of the GFC, see, Norway. Therefore, we can conclude that the GFC plays an important role for the economic growth in commodity-dependent nations. Overall, we identify the existence of break dates in the commodity-growth relationship for numerous countries, regardless the commodity sector, which may affect adversely the results from standard time-invariant models. To overcome this issue, our study adopts a time-varying MF-VAR approach.

5 | EMPIRICAL RESULTS

The empirical analysis is presented in the following steps. We begin by providing the results from the time-varying MF estimation to determine the extent to which commodity prices can predict economic growth. Then, we proceed in evaluating the growth exposure of countries' economic growth to specific commodity group, and ranking those exposure based on counties' stage of economic development: developing and developed economies. Finally, we present the results from our newly developed global commodity growth connectivity (GCGCI) index to determine the economic growth dependency on commodities over time.

5.1 | Time-varying estimation

Table 5 presents the rejection frequency results from the time-varying MF-VAR (p, h) Granger causality tests with *p* lags, which are optimally selected via the BIC, and time horizon *h*, specified as one.[9] The rejection frequency for a single country is calculated as the total number of p-values significant at 10% level is divided by the total

TABLE 3 Unit root test results

	ADF			PP			Fourier ADF		
Economic growth									
Argentina	−4.155***			−3.831***			−4.394***		
Australia	−3.414**			−3.207**			−3.608**		
Belgium	−2.677*			−3.422**			−2.767*		
Bulgaria	−3.919***			−4.326***			−4.371***		
Canada	−3.205**			−3.739***			−3.572**		
Chile	−3.928***			−3.877***			−4.267**		
Denmark	−4.038***			−5.007***			−4.425***		
Hong Kong	−4.191***			−3.981***			−4.636***		
Indonesia	−5.419***			−4.554***			−6.167***		
Malaysia	−5.866***			−3.280**			−6.187***		
Netherlands	−3.131**			−3.734***			−3.351**		
Norway	−2.768*			−5.393***			−2.972*		
Philippines	−3.930***			−4.016***			−4.332**		
Portugal	−2.890**			−3.389**			−3.125**		
Singapore	−3.964***			−3.236**			−4.191***		
South Africa	−2.641*			−3.159**			−4.119**		
South Korea	−2.882**			−3.487***			−3.987**		
Thailand	−3.487***			−3.537***			−3.748***		
Commodity prices									
	CP(τ,1)	CP(τ,2)	CP(τ,3)	CP(τ,1)	CP(τ,2)	CP(τ,3)	CP(τ,1)	CP(τ,2)	CP(τ,3)
All commodities	−4.754***	−4.729***	−4.507***	−4.522***	−4.743***	−4.183***	−4.762***	−4.991***	−4.727***
Non-fuel commodities	−4.360***	−4.264***	−4.392***	−3.754***	−3.516***	−3.557***	−4.742***	−4.591***	−4.675***
Fuel commodities	−4.814***	−4.710***	−4.696***	−4.076***	−4.288***	−4.422***	−5.225***	−5.143***	−5.270***

Note: The table reports the test statistics obtained from the unit root tests. All tests include intercept only. *, ** and *** denote the statistical significance at the 10%, 5% and 1% level respectively.

TABLE 4 Andrews' QLR (1993) test for parameter instability

Country name	All commodities		Non-fuel commodities		Fuel commodities	
	QLR tests p-values	Break dates	QLR tests p-values	Break dates	QLR tests p-values	Break dates
Argentina	0.000	Q1-1990	0.000	Q1-1990	0.119	Q1-1990
Australia	0.000	Q4-2007	0.018	Q3-2012	0.000	Q2-2012
Belgium	0.000	Q3-2007	0.139	Q3-2007	0.128	Q3-2007
Bulgaria	0.000	Q2-1994	0.000	Q2-1988	0.060	Q2-1994
Canada	0.464	Q1-2006	0.434	Q4-2005	0.000	Q3-2007
Chile	0.000	Q4-2013	0.000	Q4-2013	0.068	Q4-2013
Denmark	0.000	Q3-2000	0.000	Q3-1986	0.000	Q3-1986
Hong Kong	0.029	Q4-2010	0.379	Q4-2010	0.000	Q3-2011
Indonesia	0.000	Q4-1996	0.111	Q4-1996	0.000	Q4-1996
Malaysia	0.116	Q3-2000	0.012	Q2-1997	0.075	Q1-1997
Netherlands	0.085	Q1-2008	0.011	Q1-2008	0.000	Q1-2008
Norway	0.000	Q2-2007	0.000	Q3-2007	0.000	Q3-2007
Philippines	0.000	Q3-2011	0.000	Q3-2011	0.020	Q1-2012
Portugal	0.000	Q3-1986	0.047	Q3-1986	0.000	Q3-1986
Singapore	0.000	Q2-1994	0.000	Q2-1994	0.000	Q3-2011
South Africa	0.000	Q1-1993	0.000	Q2-1993	0.000	Q2-1993
South Korea	0.000	Q4-2010	0.000	Q1-2011	0.000	Q1-2011
Thailand	0.000	Q3-1995	0.000	Q3-1995	0.000	Q3-1995

Note: The table reports the p-values and estimated break dates from Andrews' QLR (1993) test for parameter instability.

number of rolling window tests. The null hypothesis of non-causality is specified for each rolling window.

Looking first at the commodity-to-growth results, we find solid evidence of predictability. Indeed, our results suggest that economic growth has been affected by commodity prices for all sample countries, which is typified finding that highly volatile resource revenues driven by swings in global commodity markets have explicit impact on growth in commodity dependent countries (see, Mohaddes & Raissi, 2017, for discussion). This result is also consistent with the past studies such as Gokmenoglu et al. (2016) who claim that growth in developing economies, and in their case Nigeria, is to a great extent reliant on commodities. Considering the development stage factor, we find that economic growth in developed countries have relatively larger dependency on all commodities compared to their developing counterparts. This finding is somehow in line with Cavalcanti et al. (2015). The potential explanation of this finding is that most developed nations that are economically dependent on trade, mainly import, in primary commodities have diversified industry structure and, therefore, demand for different commodities. But economic growth in numerous commodity- dependent developing countries is still highly reliant on the export of a single or few commodities and, hence, an aggregate measure of commodity prices, that is, all commodities, may not fully explain their economic growth compared to developed nations, as results show in Table 5.

Taking into consideration the non-fuel commodities, our results determine that those commodities have stronger influence on economic growth in developed economies than their developing counterparts. This evidence is somewhat consistent with the past commodity literature focusing on metals and agricultural commodities, such as, Addison et al. (2016) and Ge and Tang (2020). The intention of this finding is consistent with the high demand of developed nations for metals, mainly, for their metallurgy, steel, and chemicals sectors, as emphasized by Nechifor et al. (2020). Focusing now on the fuel commodities results, we discover that dependency of economic growth on these commodities is still existent but weaker for developed nations compared to their developing counterparts, see Table 5. This finding is somehow in line with the study by Alexeev and Chin (2021) who find that oil price shocks have small but statistically significant effects on state economies in the US. Overall, we can conclude that in recent times when more and more developed nations undergo economic transition from non-renewable to renewable energy their economic growth is likely to decrease its dependency on fossil fuels, as discussed by Adedoyin et al. (2020).

TABLE 5 Rejection frequencies from time-varying MF tests

Country	All commodities		Non-fuel commodities		Fuel commodities	
	EG ⇏ CP	CP ⇏ EG	EG ⇏ CP	CP ⇏ EG	EG ⇏ CP	CP ⇏ EG
Panel A: Developing countries						
Argentina	0.139	0.435	0.120	0.500	0.065	0.389
Chile	0.130	0.194	0.120	0.222	0.167	0.139
Hong Kong	0.287	0.593	0.102	0.435	0.139	0.537
Indonesia	0.213	0.306	0.231	0.278	0.056	0.389
Malaysia	0.315	0.389	0.315	0.398	0.083	0.500
Philippines	0.083	0.370	0.074	0.046	0.000	0.130
Singapore	0.639	0.481	0.231	0.389	0.454	0.639
South Africa	0.019	0.417	0.000	0.472	0.000	0.343
South Korea	0.417	0.444	0.250	0.454	0.333	0.759
Thailand	0.454	0.593	0.352	0.324	0.157	0.417
Panel B: Developed countries						
Australia	0.009	0.491	0.046	0.065	0.037	0.167
Belgium	0.000	0.426	0.019	0.630	0.019	0.287
Bulgaria	0.148	0.426	0.046	0.769	0.231	0.167
Canada	0.000	0.463	0.009	0.481	0.120	0.657
Denmark	0.009	0.435	0.019	0.250	0.019	0.278
Netherlands	0.000	0.435	0.000	0.565	0.000	0.046
Norway	0.000	0.657	0.000	0.231	0.009	0.185
Portugal	0.093	0.444	0.074	0.343	0.009	0.213

Note: The null hypothesis is specified as $H_0 : CP \nRightarrow EG$ (⇏ means "does not Granger-cause"). Analogously, $H_0 : EG \nRightarrow CP$ is defined.

The results from the growth-to-commodity causality context suggest that the predictive power of economic growth for commodity prices is relatively weak, especially for developed economies. This finding adds to the study by Wang and Liao (2022) who find mixed results for the economic growth impact on commodities, and in particular oil, with respect to four nations, China, India, Japan and the US. From policy perspective, our findings suggest that although economic growth is often seen as a driven for demand in commodity markets, for countries where demand-led growth exceeds productivity growth, the forecasting power of economic growth for future commodity prices is relatively weaker. Overall, our study determines substantial evidence for time-varying predictability of commodity prices for future economic growth, however, the same is not valid in the opposite direction.

5.2 | Growth dependency on specific commodity group

Table 6 shows the performance ranking for different commodities in forecasting economic growth based on the time-varying MF-VAR estimations, where the best-performing commodity is ranked 1 and the worst is ranked 3. The "average ranking" presents the average commodity rank across the given group of countries: developing and developed, whereas the "overall average ranking" denotes the average commodity rank across all countries considering the results from both developing and developed countries.

Based on the results from Table 6, we determine that the predictive power of commodity prices for future economic growth varies among different commodity groups. Considering the overall average ranking results, we can conclude that all commodities are the best predictor for future economic growth, whereas the worst one is the fuel commodities. For developed countries, all commodities, represented by the aggregate index of commodities, have better performance in predicting economic growth than either fuel or non-fuel commodities. Intriguingly, we find that fuel commodities are the weakest predictor for economic growth in developed nations, which brings implications for policymakers to consider the commodity market as a whole when designing a policy. Such evidence is consistent with the current trends of transition

TABLE 6 Performance rankings for different commodities in forecasting economic growth

	All commodities	Non-fuel commodities	Fuel commodities
Panel A: Developing countries			
Argentina	2	1	3
Chile	2	1	3
Hong Kong	1	3	2
Indonesia	2	3	1
Malaysia	3	2	1
Philippines	1	3	2
Singapore	2	3	1
South Africa	2	1	3
South Korea	3	2	1
Thailand	1	3	2
Average ranking	**1.900**	**2.200**	**1.900**
Panel B: Developed countries			
Australia	1	3	2
Belgium	2	1	3
Bulgaria	2	1	3
Canada	3	2	1
Denmark	1	3	2
Netherlands	2	1	3
Norway	1	2	3
Portugal	1	2	3
Average ranking	**1.625**	**1.875**	**2.500**
Overall average ranking	**1.778**	**2.056**	**2.167**

Note: This table presents the commodity ranking in forecasting economic growth based on the time-varying MF-VAR estimations (with the best-performing commodity ranked 1 and the worst ranked 3). The “average ranking” presents the average commodity rank across the given group of countries: developing and developed. The last row “overall average ranking” denotes the average commodity rank across all countries considering the results from both developing and developed countries.

from non-renewable to renewable energy, as discussed by Adedoyin et al. (2020). For developing nations, our results show that the worst performing commodity group in forecasting economic growth is non-fuel commodities. This finding is somehow consistent with the past study by Addison et al. (2016) who find weak evidence for the impact of agricultural commodity price shocks on economic growth in Sub-Saharan Africa countries. At the same time, both all commodities and fuel commodities have equal power in forecasting future economic growth in developing economies. Overall, our findings apprise that all commodities have a stronger predictability power than either non-fuel or fuel commodities for future economic growth among all sample countries, with overall average ranking of 1.778.

Moreover, we find that the dependency of economic growth on different commodity groups is contingent on the country stage of economic development. Specifically, economic growth in developed economies is least dependent on fuel commodities, whereas growth in developing nations is least dependent on non-fuel commodities. In fact, we find that fuel commodities are listed as the best predictor for economic growth only for one developed nation, Canada, and four developing countries, Indonesia, Malaysia, Singapore and South Korea. This outcome contrasts to a certain extent with the results of Narayan et al. (2014) who find evidence of oil price predictability for future economic growth with greater evidence of predictability for developed countries.

To determine whether economic growth has reduced, or increased, its dependency on commodity markets over time, we have to look more closely at the exact time periods of (possible) changes in the relationship between commodity markets and economic growth. To address this, we develop a new index of global commodity growth connectivity (GCGCI) to determine the economic growth

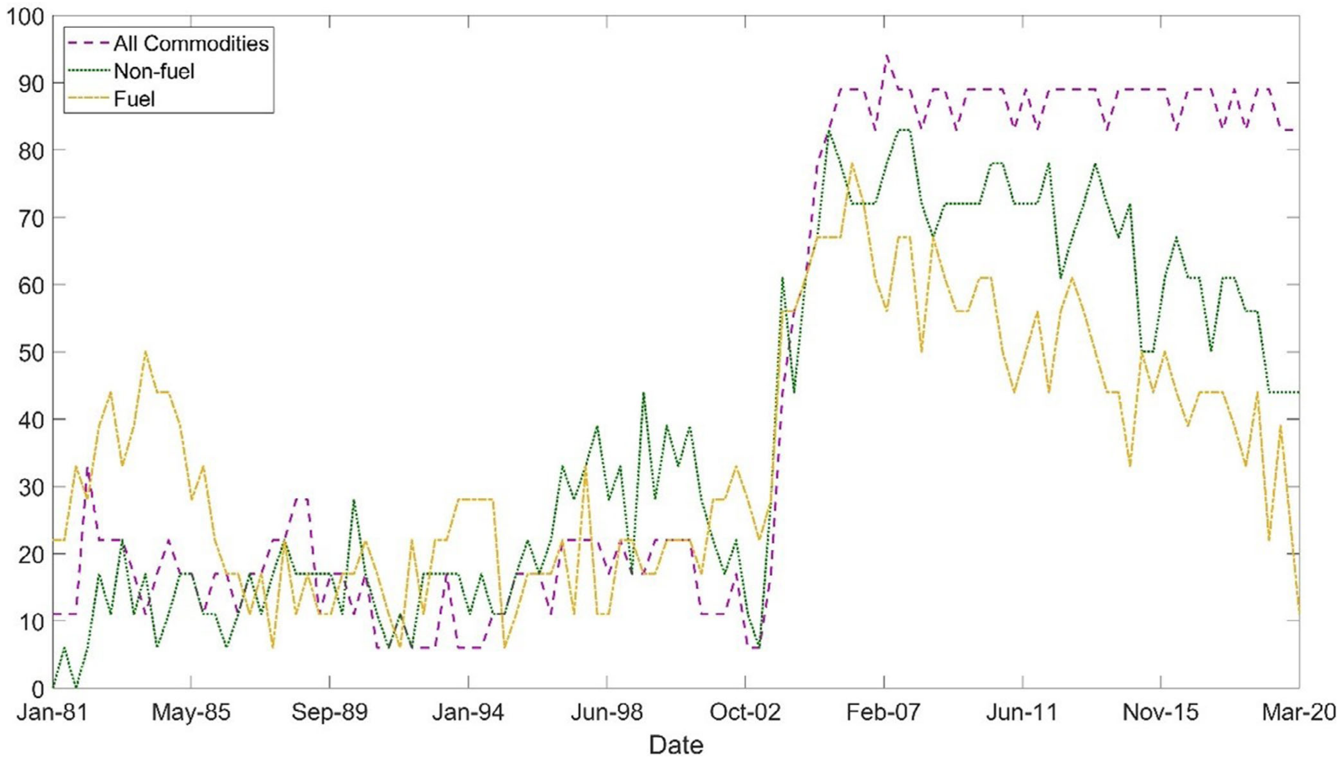

FIGURE 1 Global commodity growth connectivity index, all countries. The index ranges from 0 to 100. All commodities denotes the GCGCI all commodities index, fuel denotes GCGCI fuel index, and non-fuel is the GCGCI Non-fuel index. [Colour figure can be viewed at wileyonlinelibrary.com]

dependency on commodities over time, which results are presented in the next section.

5.3 | Global commodity growth connectivity index: All countries

A seldom but growing literature investigates the existence of commodity-growth relationship in a time-varying context, however, not much is known on the periods of strong and weak growth dependency on commodity prices over time. To address this, we use our newly constructed indexes of global commodity growth connectivity: GCGCI All Commodities, GCGCI Fuel, and GCGCI Non-fuel. Each of the indexes is constructed in the following forms: all countries as a whole, developing and developed economies. To begin with, we consider the results from GCGCI indexes for all countries as shown in Figure 1.

Figure 1 shows that connectivity has a period average of around 20 percent between 1981 and 2003, while it exhibits a rapid increase after the early 2000s for all three commodity groups. This finding suggests that growth dependency on commodities has been volatile over time and mostly determined by the periods of economic uncertainty, as highlighted by Tahar et al. (2021). Besides, the growth dependency on fuels is much larger than on the other proxies in the 1980s, which may be explained by the 1979 energy crisis, which saw oil prices rising sharply in 1979 and early 1980. The 1979 energy crisis was a key event leading to the early 1980s recession which has adverse effect on the economic development of numerous countries around the globe. This finding confirms the claims of Hamilton (2009) that oil prices play an important role in explaining the trends in economic growth.

Not only fuels but also non-fuel commodities play a role in explaining economic growth as can be seen from the period of the 1997 Asian financial crisis. In the period of late 1990s, numerous Asian economies act as major exporters of agricultural and metal products and, hence, exert a large impact on the world prices of these commodities. As such, the economic downturn embodied in the 1997 Asian financial crisis has increased not only the Asian growth dependency on world non-fuel prices but also the growth dependency in other nations around the world that rely on the non-fuel commodities import. Therefore, our findings determine that the 1997 Asian financial crisis had an impact on the commodity-growth relationship and this impact was not restricted to the particular region but spread globally.

Nonetheless, the subsequent period from 2004 through 2006 is characterized with progressive upsurge in growth dependency on commodity markets, as documented in Figure 1, which coincides with the financialization of commodity markets (see, Basak & Pavlova, 2016; Cheng & Xiong, 2014; Eberhardt & Presbitero, 2021; Tang & Xiong, 2012). Although numerous studies have investigated the equity-commodity correlation and most find that it increases remarkably with the financialization of commodity markets (Basak & Pavlova, 2016), our study contributes to the limited but growing literature on forecasting economic growth using commodity prices. We find that growth dependency on commodity prices has increased at least three times after the financialization with GCGCI reaching values of around 80 percent, see Figure 1. Worth to point is that this result holds regardless the commodity group. From economic point of view, our findings are consistent with Kilian (2009) who claims that the strong commodity demand from China and other emerging economies coupled with a stagnant commodity supply at that time is the key factor in explaining the commodity price boom in the early 2000s, as our index shows, has result in increased growth dependency on commodity markets. We can conclude that the growth dependency on commodity markets after their financialization has been enhanced by the large pool of institutional investors who enter simultaneously the derivative market of commodity futures as well as by the information frictions in the global supply, demand, and inventory of commodities during that period, which as highlighted by Cheng and Xiong (2014) has tighten the equity-commodity link but also, as our results show in Figure 1, marks a massive economic growth dependency on commodity prices.

Moreover, we can notice that growth dependency on commodity markers, and in particular on the disaggregated commodity groups, has weaken after it reaches its peak in mid-2000s. A possible explanation of this may be the lack of investor confidence in bank solvency and drops in credit availability, specifically the 2007–2008 global financial crisis (GFC), that led to sinking stock and commodity prices in late 2008 and early 2009 and, hence, weaken the role of commodity prices as a leading factor for future economic growth. The impact of the GFC on the commodity-growth relationship can be seen from both GCGCI fuel and non-fuel indexes, as shown in Figure 1, which exhibit gradually declining trend during the spread of the GFC. Noteworthy, our indexes show that GCGCI non-fuel commodities has higher value than its fuel alternative in years after the GFC and, therefore, we can conclude that growth dependency on non-fuel commodities is higher than on their fuel counterparts. This evidence is somewhat consistent with the fact that the percentage of mineral-dependent countries doubled during the last 20 years as highlighted by UNCTAD (2021). Nonetheless, our finding implies a declining trends of growth dependency on both fuel and non-fuel commodities after the onset of the GFC, which may be a result from stagnation in industrial production, but also due to a high uncertainty in energy markets (Balcilar & Bekun, 2020a; Pan et al., 2017), which triggers economic transition from non-renewable to renewable energy, which is likely to decrease economic growth dependency on fossil fuels, as discussed by Adedoyin et al. (2020).

Overall, we find that connectivity has a period average of around 90 percent after the onset of the GFC. Such prevalence of causality is not determined for neither fuel nor non-fuel markets at any point in time. Therefore, we can confidently conclude that economic growth has mainly been impacted by commodity market, as a whole, and to a lesser extent by its segments in the post-GFC period, as shown in Figure 1. From policy perspective, our finding reveals that numerous countries have reduced their growth dependency on both fuel and non-fuel commodities after the onset of the GFC. This can be seen as an attempt of policy makers to cushion the effect of high uncertainty triggered by the GFC on commodity markets, which may adversely impact growth in commodity-dependent economies, especially, those that specialize in a single or few commodities.

5.4 | Global commodity growth connectivity index: Developing and developed countries

This section looks at more niche level at the growth dependency on commodities considering separate GCGCI indexes for developing and developed nations. In fact, we investigate whether the growth exposure of our sample countries to specific commodity group is subject to the stage of their economic development. To determine this, we consider separate GCGCI indexes for developing and developed countries as presented in Figures 2 and 3, respectively.

Figures 2 and 3 show that commodity sector plays a foremost role for future economic growth for both developing and developed nations, especially, after the financialization of commodity markets. Causality moderately runs from commodities to economic growth in the 1980s to throughout the mid-1990s, with a nadir of growth dependency on commodity prices at early 2000s. This evidence is in conjunction with the trends in growth dependency on commodity markets at their pre-financialization stage (Basak & Pavlova, 2016).

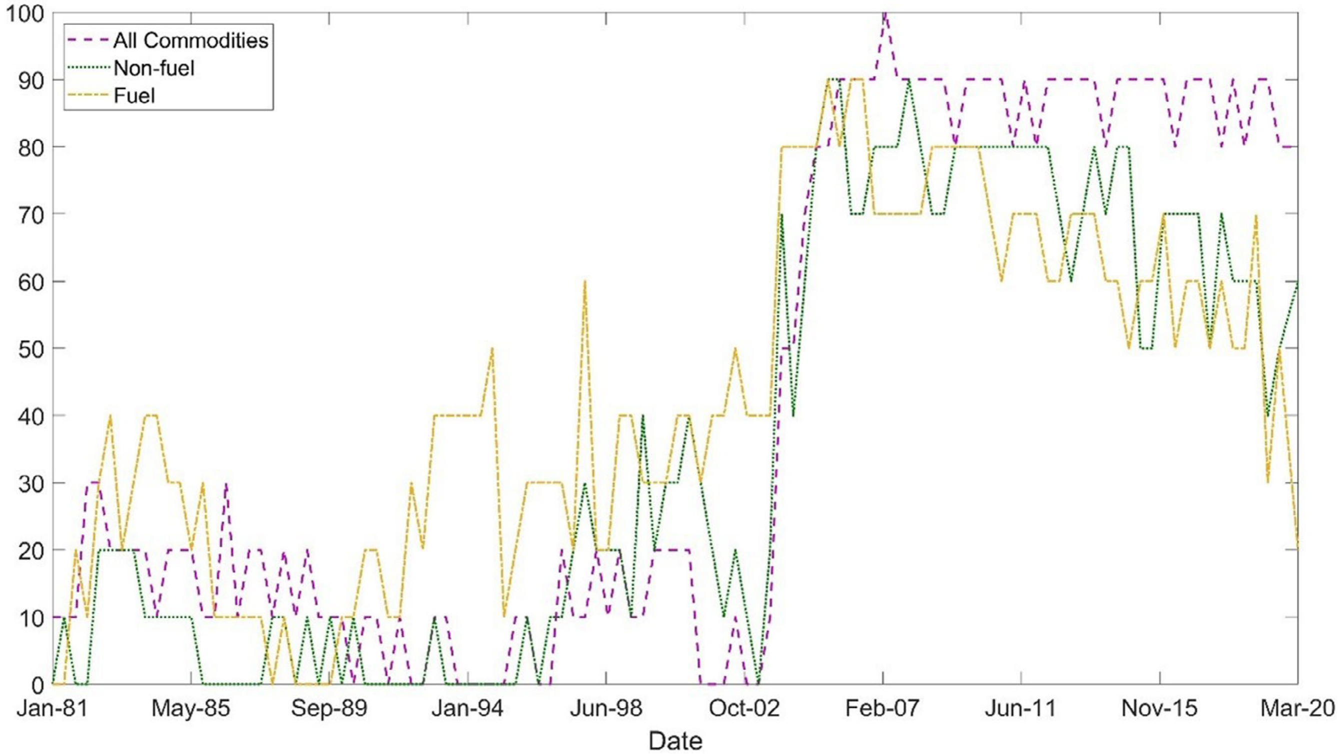

FIGURE 2 Global commodity growth connectivity index, developing countries. The index ranges from 0 to 100. All commodities denotes the GCGCI all commodities index, fuel denotes GCGCI fuel index, and non-fuel is the GCGCI Non-fuel index. [Colour figure can be viewed at wileyonlinelibrary.com]

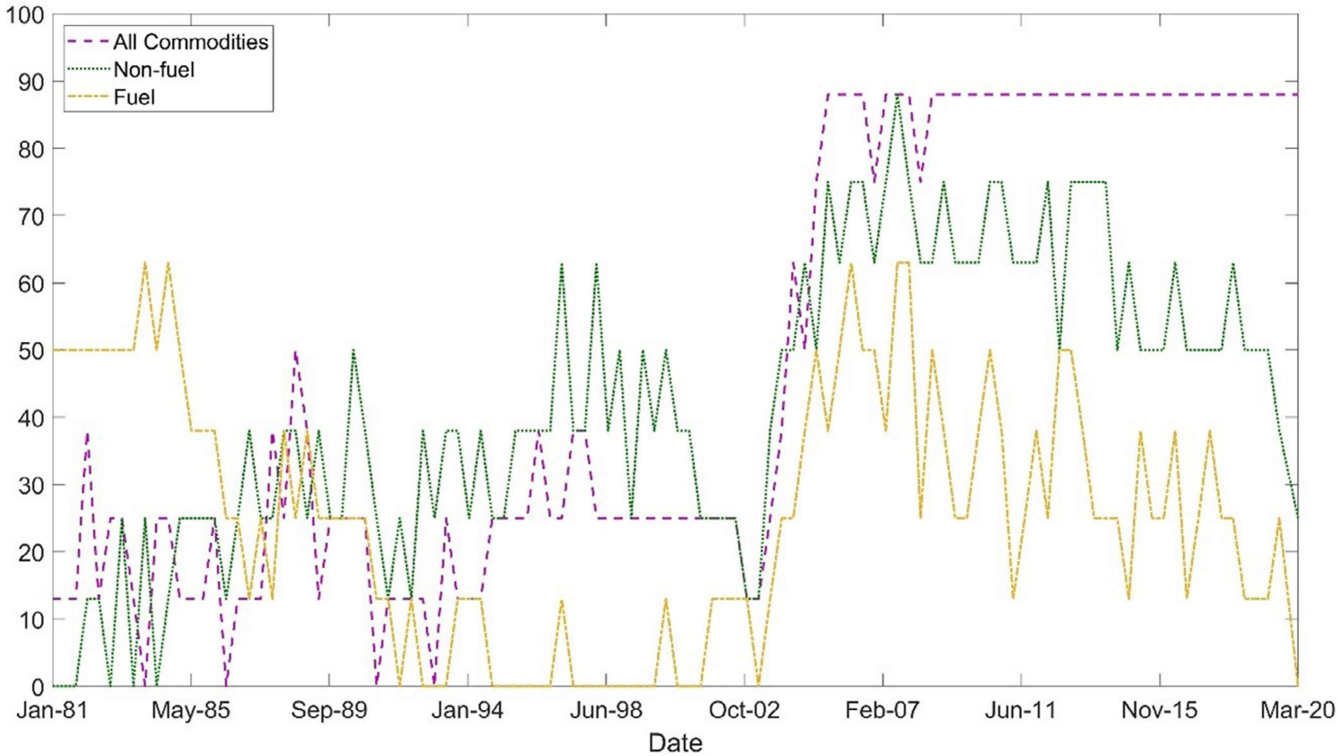

FIGURE 3 Global commodity growth connectivity index, developed countries. The index ranges from 0 to 100. All commodities denotes the GCGCI all commodities index, Fuel denotes GCGCI fuel index, and non-fuel is the GCGCI non-fuel index. [Colour figure can be viewed at wileyonlinelibrary.com]

Further to that, we determine diverse impact of commodity prices on economic growth in terms of developing and developed economies. Evidently large divergency among the GCGCI indexes is noticed during the Great Commodities Depression of the 1980s and 1990s, as shown in Figures 2 and 3. In fact, the GCGCI for all commodities shows a period average of around 21 percent for developed and 12 percent for developing economies between 1980 and 2000. This suggest that the impact of all commodities on growth in developed economies is almost twice larger than in their developing counterparts. Similarly, we find that GCGCI for non-fuel commodities has a period average of around 28 percent for developed and 8 percent for developing economies between 1980 and 2000. This finding signifies that non-fuel commodities have least power for predicting future economic growth in developing economies during the Great Commodities Depression. Also, our findings are in line with those of Tahar et al. (2021) who use commodity terms-of-trade index and determine asymmetry in the commodity-growth relationship. Considering the fuel commodities, we find that growth in both developed and developing countries is affected by commodity prices on average of around 22 percent. Hence, we can conclude that the impact of fuel commodities on growth in the pre-financialization of commodity markets times remains roughly unaffected by the stage of economic development. This outcome adds to the study of Narayan et al. (2014) on whether stage of development matters for growth dependency on fuel commodities.

Interesting to observe is the growth dependency on commodities during the 1997 Asian financial crisis. During the crisis, we can notice that all commodities have slightly increased their impact on growth for developed economies, but for their developing counterparts, on average, the impact remains almost unchanged. However, the Asian financial crisis period is characterized with substantial shifts in the growth dependency on non-fuel and fuel commodities for both developing and developed economies. With respect to GCGCI non-fuel commodities, we observe that growth dependency in developed countries almost doubled whereas for developing economies it almost tripled compared to their respective period average for the period from 1980 to 2000. This finding suggests that the times of Asian financial crisis are characterized with increase in growth dependency on non-fuel commodities regardless the stage of economic development. The results from GCGCI fuel commodities are even more intriguing. The period during the Asian financial crisis is determined by a huge decline in growth dependency on fuel commodities in developed economies, but at the same time, growth in developing countries becomes more dependent on fuels. This evidence contrasts with Narayan et al. (2014) who find greater evidence of oil price predictability for future economic growth for developed countries than their developing counterparts. In sum, we can conclude that the 1997 Asian financial crisis brought changes to the commodity-growth relationship with most commodity groups mark an increase in their predictive power for future economic growth, but others, such as fuels, decrease their forecasting ability in developed economies.

The subsequent period from 2000s onwards is characterized with progressive upsurge in growth dependency on commodity markets, as documented in Figures 2 and 3. In fact, we observe that financialization of commodity markets times exhibit some interesting reversals in the commodity-growth relationship. Our results from GCGCI all commodities show a period average of around 90 percent between 2004 and 2020, for both developing and developed economies, whereas developing nations pertain slightly higher average values. This finding is in line with Jacks et al. (2011) that growth dependency on commodities in developing economies is slightly higher than in their developed counterparts. Nonetheless, all commodities remain the best predictor for future economic growth for both developed and developed economies and the subsequent GFC does not interfere this tendency. At the same time, GCGCI for fuel commodities shows decrease in the growth dependency on fuel commodities for both developing and developed nations. In fact, both fuel and non-fuel GCGCIs exhibit declining trend after they reach their peak before the onset of the GFC. For developing economies, economic growth weakens its dependency on both non-fuel and fuel commodities as time elapse, with the two commodity groups perform relatively similar as predictors for future economic growth. Considering developed economies, we find that non-fuel commodities decrease their predictive power for economic growth, however, they remain its superior predictor to fuel commodities with minor exemption in 2012. In these lines, the fuel commodities almost lost their power as predictor for future economic growth for developed economies after the GFC. However, fuel commodities still remain an important factor determining economic growth in developing economies, as shown in Figure 2.

In sum, we can conclude that growth dependency on commodities varies with respect to specific commodity group and the country stage of economic development. We determine that commodity market, as a whole, is the best predictor for future economic growth in both developing and developed economies after the 2000s commodities boom and the subsequent GFC. This finding reveals a swing in the common tendency of growth dependency on a single or few commodities as the results show in the late XX century. From policy perspective, the rate of

TABLE 7 Total number of countries persisting causality across different horizons

	Horizon = 1		Horizon = 2		Horizon = 3		Horizon = 4		Horizon = 6	
	EG ⇏ CP	CP ⇏ EG	EG ⇏ CP	CP ⇏ EG	EG ⇏ CP	CP ⇏ EG	EG ⇏ CP	CP ⇏ EG	EG ⇏ CP	CP ⇏ EG
All commodities										
Developing	10(10)	10(10)	9(10)	10(10)	10(10)	9(10)	8(10)	8(10)	8(10)	10(10)
Developed	4(8)	8(8)	8(8)	8(8)	6(8)	8(8)	7(8)	8(8)	5(8)	8(8)
Total	14(18)	18(18)	17(18)	18(18)	16(18)	17(18)	15(18)	16(18)	13(18)	18(18)
Non-fuel commodities										
Developing	9(10)	10(10)	9(10)	10(10)	9(10)	8(10)	9(10)	7(10)	7(10)	4(10)
Developed	6(8)	8(8)	7(8)	8(8)	7(8)	8(8)	5(8)	8(8)	8(8)	7(8)
Total	15(18)	18(18)	16(18)	18(18)	16(18)	16(18)	14(18)	15(18)	15(18)	11(18)
Fuel commodities										
Developing	8(10)	10(10)	9(10)	9(10)	9(10)	8(10)	7(10)	6(10)	9(10)	8(10)
Developed	7(8)	8(8)	6(8)	8(8)	5(8)	7(8)	4(8)	5(8)	5(8)	6(8)
Total	15(18)	18(18)	15(18)	17(18)	14(18)	15(18)	11(18)	11(18)	14(18)	14(18)

Note: The table presents the number of countries for which time-varying Granger causality has been detected, that is, rejection frequency is higher than zero. In brackets is given the total sample of countries tested. The null hypothesis is specified as H_0 : CP ⇏ EG (⇏ means "does not Granger-cause"). Analogously, H_0 : EG ⇏ CP is defined.

globalization has increased in recent years, which can be seen as a factor that influences trade openness and, hence, accessibility for commodities in the world market. The latter is enhanced by the post-GFC efforts of policy makers to reduce the impact of certain commodity groups on national economies in order those to achieve sustainable growth.

6 | ROBUSTNESS CHECK

6.1 | Long-horizon predictability

The existing literature has raised concerns that commodity price predictability may vary with the forecasting horizon (see, Gargano & Timmermann, 2014). Therefore, to address this point, we conduct a sensitivity analysis using four different forecasting horizons: $h=2$, $h=3$, $h=4$, and $h=6$. Consistent with our main estimation framework, the rejection frequency is derived from the time-varying MF-VAR (p, h) Granger causality tests with p lags, which are optimally selected via the BIC, but now the time horizon h is specified as $h \in \{2,3,4,6\}$. The rejection frequency for a single country is calculated as the total number of p-values significant at 10% level is divided by the total number of rolling window tests. The null hypothesis of non-causality is specified for each rolling window.

Table 7 presents the number of countries for which time-varying Granger causality has been detected, that is, rejection frequency is higher than zero, for horizons $h \in \{2,3,4,6\}$. Our estimation results indicate that the long-horizon commodity predictability for future economic growth slightly weakens but remains collectively consistent throughout different time horizons. This finding is somehow in line with the prevailing view in the forecasting literature that the short-run impact of the commodity prices on economic growth vanishes in the long run (Ferraro & Peretto, 2018). Nonetheless, we find evidence of commodity prices predictability for future economic growth for no less than three-fifths of all sample countries considering all forecasting horizons and commodity groups. This is a credible support for our main findings on the role that commodity prices play in forecasting future economic growth.[10]

6.2 | Does proxy choice matter? Evidence from three alternative proxies

This section acts as a sensitivity check for our empirical outcomes with respect to the proxy choice for aggregate index of world commodity prices. We use three different proxies for world commodity prices to check the robustness of our main results: Goldman Sachs Commodity Price Index (GSCI), Moody's (Moody's) and Thomson Reuters Core Commodity Equal Weighted Index (TR CCI). The three alternative commodity indexes differ from our main proxy for *all commodities*, CRB (BLS) Spot Price Index (CRB), in terms of their index basket composition and its weighting structure.[11]

TABLE 8 Total number of countries persisting causality across alternative proxies

	CRB		GSCI		Moody's		TR CCI	
	EG ⇏ CP	CP ⇏ EG	EG ⇏ CP	CP ⇏ EG	EG ⇏ CP	CP ⇏ EG	EG ⇏ CP	CP ⇏ EG
Developing	10(10)	10(10)	9(10)	10(10)	9(10)	10(10)	10(10)	10(10)
Developed	4(8)	8(8)	5(8)	8(8)	5(8)	8(8)	6(8)	6(8)
Total	14(18)	18(18)	14(18)	18(18)	14(18)	18(18)	16(18)	16(18)

Note: The table presents the number of countries for which time-varying Granger causality has been detected, that is, rejection frequency is higher than zero. In brackets is given the total sample of countries tested. The null hypothesis is specified as H_0 : CP ⇏ EG (⇏ means "does not Granger-cause"). Analogously, H_0 : EG ⇏ CP is defined.

Table 8 shows the results from the three alternative proxies based on the time-varying MF-VAR (p, h) Granger causality tests with p lags, which are optimally selected via the BIC, and time horizon h, specified as one.[12] In other words, the table reports the number of countries for which time-varying Granger causality has been detected, that is, rejection frequency is higher than zero. To allow for a comparison, we include a brief summary of the results from CRB, that is, our main proxy for *all commodities*. Our findings reveal that CRB and TR CCI provide relatively similar evidence for the predictive power of commodity prices for future economic growth. Specifically, the two indexes CRB and TR CCI differ in the way they weigh their basket of commodities. While the former index unequally weighs each individual commodity, the latter equally weighs all commodity products, which implies that the latter is immune to the volume effect and reflect only the prices movements (see, Deaton & Miller, 1995). Therefore, this finding provides support to our main results that those are unaffected by the weighting structure of the index proxy. Further to that, we determine that CRB, Moody's and GSCI lead to identical outcomes in terms of commodity-to-growth causality, regardless the level of economic development, but slight discrepancy is spotted in case of reverse causality results, see Table 8. Overall, our results from the robustness analysis confirm that the forecasting power of commodity prices for future economic growth remains nearly unaffected by the choice of index proxy for world commodity prices and, in particular, the index basket composition and its weighting structure.

7 | CONCLUSIONS AND POLICY IMPLICATIONS

This paper investigates the extent to which commodity prices can predict economic growth, the growth exposure of the countries to specific commodity group, and whether the country stage of development matters for growth dependency on commodities. We use a novel time-varying mixed-frequency vector autoregressive model to jointly estimate causality between monthly commodity prices and quarterly economic growth for the period from January 1980 to March 2020. Using a set of 18 commodity-dependent countries, 10 are developing and the balance is developed countries, we determine that growth dependency on commodities varies over time and across different synthetic measures, but in general solid evidence of predictability is determined.

Our results suggest the economic growth has been affected by commodity prices for all sample countries, which is typified finding that highly volatile resource revenues driven by swings in global commodity markets have explicit impact on growth in commodity dependent countries. In other words, the overall commodity index shows a better performance in predicting economic growth than the segregated proxies of either fuel or non-fuel commodities in developed economies. However, the overall commodity index is as effective as the fuel index in predicting economic growth for their developing counterparts. Taking into consideration the non-fuel commodities, our results determine that those commodities have stronger influence on economic growth in developed economies than their developing counterparts. However, the fuel commodities results suggest that the dependency of economic growth on these commodities is still existent but weaker for developed nations compared to their developing counterparts. Overall, we conclude that commodity prices act as a leading indicator for future economic growth, but countries' growth is affected to a dissimilar extent from different commodity groups.

Further, we develop a new index of global commodity growth connectivity (GCGCI) to determine the economic growth dependency on commodities over time. Our results show that economic growth dependency on commodities has increased at least three times with financialization of commodity markets. The GCGCI for all commodities reveals a higher growth dependency on commodities in developing countries than developed ones in the post-financialization period. Intriguingly, we find that growth decreases its reliance on fuel commodities in both developed and developing countries after financialization of commodity markets. Moreover, our findings show that connectivity has a period average of around 90 percent after the onset of the GFC. Such prevalence of causality is not determined for neither fuel nor non-fuel markets at any point in time. At the same time, our findings reveal that numerous countries have reduced their growth dependency on both fuel and non-fuel commodities after the onset of the GFC. Therefore, we can confidently conclude that economic growth has mainly been impacted by commodity market, as a whole, and to a lesser extent by its segments after the GFC.

This study brings important recommendations for policymakers in terms of economic growth dependency on commodities with respect to country stage of development. In fact, policymakers can use the predictive power of commodity prices to establish such strategies that reduce the commodity harmfulness on economic growth. Achieving this requires a comprehensive approach to commodity management embedded within a broad sustainable development strategy, careful management of resource revenues and firm policy commitments. Our results provide incentives towards the UN (2019) key policy objectives that commodity-dependent countries need to address – building resilience against volatility, expanding linkages from the commodity sector to the rest of the economy and developing necessary human and physical capital. Furthermore, policy makers should adopt countercyclical fiscal policies, accumulating savings during times of commodity price booms, and raising government spending when commodity prices are low to compensate for the economic slowdown in countries dependent on commodity exports. In the opposite way may act policy makers for those countries that are dependent on commodity imports. In this aspect, commodity-dependent economies can potentially establish revenue stabilization funds as buffers against commodity price fluctuations. Our advice to the advisory boards of revenue stabilization funds is to explore the findings reported in this study to enhance their understandings on the growth dependence on commodities and, especially, its exposure to specific commodity group.

A major limitation of this study is its limited sample of countries, which is determined by the data availability for quarterly economic growth series. A future study must consider a broader set of countries, potentially using annual data on economic growth, to test the growth dependency on monthly commodity prices.

The limitation of this study is that the analysis is constrained by testing the growth dependency on commodities for a limited sample of countries, which choice is determined by the data availability for quarterly economic growth series. To provide a more comprehensive scenario regarding the growth dependency on different commodities, future researchers should incorporate a broader set of commodity groups, or specific even commodities, in their studies.

In this paper, we constrain our analysis to the economic growth dependency on commodity prices. Future research can explore the interaction between commodity prices and other channels of the economy such as exchange rates and inflation. In addition, our research focuses on the causal link between economic growth and commodity prices, our research design can be applied to study the impact of commodity shocks on economic growth, e.g., impose restrictions on the sign of shocks within the MF-VAR framework to test various scenarios and policies.

ACKNOWLEDGEMENTS

The author would like to thank the Editor Joscha Beckmann and three anonymous reviewers for their valuable comments. I am grateful to Atanu Ghoshray, Betty Simkins, Eric Ghysels, Giorgio Fazio, Giuseppe Cavaliere, Tapas Mishra, Wei Wang and participants at the RES 2019 PhD Meetings and Job Market conference, Shaanxi Silk Road International Symposium for Distinguished Young Scholars, XXII Applied Economics Meeting, for helpful comments, discussions and suggestions. Of course, the usual caveat applies.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author.

ORCID

Martin Enilov https://orcid.org/0000-0002-7671-6975

ENDNOTES

[1] A country is commodity-dependent if commodities account for more than 60 percent of its total merchandise exports value as per the United Nations Conference on Trade and Development definition (UNCTAD, 2013). The estimation is based on author's calculations based on data from UN Comtrade (2022).

[2] The definition of "Periphery" nations, as stated by the authors, includes Denmark, Greece, Norway, Portugal, Russia, Sweden, Serbia, Spain, Australia, Canada, New Zealand, Argentina, Brazil, Chile, Colombia, Cuba, Mexico, Peru, Uruguay, Burma, Ceylon, China, Egypt, India, Indonesia, Japan, Philippines, Thailand and Turkey, while the "Core" nations includes Austria, France, Germany, Italy, the United Kingdom and the US.

[3] We attempted a model specification with a constant term in Equation (1) and found that the inclusion of a constant term does not lead to significant quantitative changes in the empirical results.

[4] Following Ghysels et al. (2016), we use Newey and West's (1987) kernel-based HAC covariance estimator with Newey and West's (1994) automatic bandwidth selection.

[5] The grouping of countries is made based on the World Bank Analytical Classifications as of April 2020.

[6] Following Makhlouf et al. (2017), we select our sample of commodity-dependent countries as those with a ratio of primary commodity exports (imports) to GDP that exceeds 7%. This leads to the exclusion of 20 countries from our sample (see Appendix A). In addition, to construct a balanced dataset that allows comparison over time we also drop: Croatia, Czech Republic, Hungary, Iraq, New Zealand, Russia, Slovakia and Venezuela.

[7] Hereafter, we will refer to the WTI crude oil prices as "fuel commodities" and, respectively, CRB (BLS) Spot Price Index refers to "all commodities", IMF non-fuel price index denotes "non-fuel commodities".

[8] The test against a one-time reversal is implemented with trimming values 0.15 and 0.85.

[9] The maximum lag length is set to four, which is consistent with the past works of Kuzin et al. (2011) and Bai et al. (2013).

[10] Individual countries' rejection frequencies for different horizons are provided in Appendix B.

[11] For a broader discussion of index number formulas see Diewert (1976).

[12] Individual countries' rejection frequencies for alternative proxies are provided in Appendix C.

REFERENCES

Adams, F. G., Behrman, J. R., & Roldan, R. A. (1979). Measuring the impact of primary commodity fluctuations on economic development: Coffee and Brazil. *American Economic Review*, *69*(2), 164–168.

Addison, T., Ghoshray, A., & Stamatogiannis, M. P. (2016). Agricultural commodity price shocks and their effect on growth in sub-Saharan Africa. *Journal of Agricultural Economics*, *67*(1), 47–61.

Adedoyin, F. F., Bekun, F. V., & Alola, A. A. (2020). Growth impact of transition from non-renewable to renewable energy in the EU: The role of research and development expenditure. *Renewable Energy*, *159*, 1139–1145.

Agboola, M. O., Bekun, F. V., & Joshua, U. (2021). Pathway to environmental sustainability: Nexus between economic growth, energy consumption, CO2 emission, oil rent and total natural resources rent in Saudi Arabia. *Resources Policy*, *74*, 102380.

Alexeev, M., & Chih, Y. Y. (2021). Energy price shocks and economic growth in the US: A state-level analysis. *Energy Economics*, *98*, 105242.

Andrews, D. W. (1993). Tests for parameter instability and structural change with unknown change point. *Econometrica*, *61*(4), 821–856.

Bai, J., Ghysels, E., & Wright, J. H. (2013). State space models and MIDAS regressions. *Econometric Reviews*, *32*(7), 779–813.

Balcilar, M., & Bekun, F. V. (2020a). Do oil prices and exchange rates account for agricultural commodity market spillovers? Evidence from the Diebold and Yilmaz index. *Agrekon*, *59*(3), 366–385.

Balcilar, M., & Bekun, F. V. (2020b). Spillover dynamics across price inflation and selected agricultural commodity prices. *Journal of Economic Structures*, *9*(1), 1–17.

Basak, S., & Pavlova, A. (2016). A model of financialization of commodities. *The Journal of Finance*, *71*(4), 1511–1556.

Baumeister, C., & Guérin, P. (2021). A comparison of monthly global indicators for forecasting growth. *International Journal of Forecasting*, *37*(3), 1276–1295.

Baumeister, C., & Peersman, G. (2013). Time-varying effects of oil supply shocks on the US economy. *American Economic Journal: Macroeconomics*, *5*(4), 1–28.

Beck, S. (2001). Autoregressive conditional heteroscedasticity in commodity spot prices. *Journal of Applied Econometrics*, *16*(2), 115–132.

Bekaert, G., & Harvey, C. R. (2002). Research in emerging markets finance: Looking to the future. *Emerging Markets Review*, *3*(4), 429–448.

Bekaert, G., Hoerova, M., & Duca, M. L. (2013). Risk, uncertainty and monetary policy. *Journal of Monetary Economics*, *60*(7), 771–788.

Ben-Rephael, A., Kandel, S., & Wohl, A. (2012). Measuring investor sentiment with mutual fund flows. *Journal of Financial Economics*, *104*(2), 363–382.

Berument, M. H., Ceylan, N. B., & Dogan, N. (2010). The impact of oil price shocks on the economic growth of selected MENA1 countries. *The Energy Journal*, *31*(1), 149–176.

Billio, M., Getmansky, M., Lo, A. W., & Pelizzon, L. (2012). Econometric measures of connectedness and systemic risk in the finance and insurance sectors. *Journal of Financial Economics*, *104*(3), 535–559.

Blattman, C., Hwang, J., & Williamson, J. G. (2007). Winners and losers in the commodity lottery: The impact of terms of trade growth and volatility in the periphery 1870–1939. *Journal of Development Economics*, *82*(1), 156–179.

Bleaney, M., & Greenaway, D. (2001). The impact of terms of trade and real exchange rate volatility on investment and growth in sub-Saharan Africa. *Journal of Development Economics*, *65*(2), 491–500.

Borenstein, S., Cameron, A. C., & Gilbert, R. (1997). Do gasoline prices respond asymmetrically to crude oil price changes? *The Quarterly Journal of Economics*, *112*(1), 305–339.

Brückner, M., & Ciccone, A. (2010). International commodity prices, growth and the outbreak of civil war in sub-Saharan Africa. *The Economic Journal*, *120*(544), 519–534.

Carter, C. A., & Smith, A. (2011). Commodity booms and busts. *Annual Review of Resource Economics*, *3*(1), 87–118.

Cashin, P., Céspedes, L., & Sahay, R. (2004). Commodity currencies and the real exchange rate. *Journal of Development Economics*, *75*(1), 239–268.

Cavalcanti, D. V., Mohaddes, K., & Raissi, M. (2011). Does oil abundance harm growth? *Applied Economics Letters*, *18*(12), 1181–1184.

Cavalcanti, D. V., Tiago, V., Mohaddes, K., & Raissi, M. (2015). Commodity price volatility and the sources of growth. *Journal of Applied Econometrics*, *30*(6), 857–873.

Chen, Y. C., & Rogoff, K. (2003). Commodity currencies. *Journal of International Economics*, *60*(1), 133–160.

Chen, Y. C., Rogoff, K. S., & Rossi, B. (2010). Can exchange rates forecast commodity prices? *The Quarterly Journal of Economics*, *125*(3), 1145–1194.

Chen, Y. C., Turnovsky, S. J., & Zivot, E. (2014). Forecasting inflation using commodity price aggregates. *Journal of Econometrics*, *183*(1), 117–134.

Cheng, I. H., & Xiong, W. (2014). Financialization of commodity markets. *Annual Review of Financial Economics*, *6*(1), 419–441.
Ciccone, A. (2018). International commodity prices and civil war outbreak: New evidence for sub-Saharan Africa and beyond. CESifo Working Paper, No. 6866. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3144266
Clements, M. P., & Galvão, A. B. (2008). Macroeconomic forecasting with mixed-frequency data: Forecasting output growth in the United States. *Journal of Business & Economic Statistics*, *26*(4), 546–554.
Collier, P., & Goderis, B. (2008). Commodity prices, growth, and the natural resource curse: Reconciling a conundrum. Working paper, University of Oxford, Mimeo.
Collier, P., & Goderis, B. (2012). Commodity prices and growth: An empirical investigation. *European Economic Review*, *56*(6), 1241–1260.
Comtrade, U. N. (2022). *United Nations Statistics Division. UN Comtrade*. https://comtrade.un.org/
Cross, J., & Nguyen, B. H. (2017). The relationship between global oil price shocks and China's output: A time-varying analysis. *Energy Economics*, *62*, 79–91.
Cuñado, J., & De Gracia, F. P. (2003). Do oil price shocks matter? Evidence for some European countries. *Energy Economics*, *25*(2), 137–154.
Cuñado, J., & De Gracia, F. P. (2005). Oil prices, economic activity and inflation: Evidence for some Asian countries. *The Quarterly Review of Economics and Finance*, *45*(1), 65–83.
De Broeck, M., & Sløk, T. (2006). Interpreting real exchange rate movements in transition countries. *Journal of International Economics*, *68*(2), 368–383.
Deaton, A. (1999). Commodity prices and growth in Africa. *Journal of Economic Perspectives*, *13*(3), 23–40.
Deaton, A., & Laroque, G. (1992). On the behaviour of commodity prices. *The Review of Economic Studies*, *59*(1), 1–23.
Deaton, A., & Miller, R. I. (1995). *International commodity prices, macroeconomic performance, and politics in sub-Saharan Africa*. Princeton University Printing Services.
Dehn, J. (2000). *Commodity Price uncertainty and shocks: Implications for economic growth*. The Centre for the Study of African economies working paper series, No. 2000-10.
Dickey, D. A., & Fuller, W. A. (1979). Distribution of the estimators for autoregressive time series with a unit root. *Journal of the American Statistical Association*, *74*(366a), 427–431.
Diewert, W. E. (1976). Exact and superlative index numbers. *Journal of Econometrics*, *4*(2), 115–145.
Eberhardt, M., & Presbitero, A. F. (2021). Commodity prices and banking crises. *Journal of International Economics*, *131*, 103474.
Edelstein, P., & Kilian, L. (2009). How sensitive are consumer expenditures to retail energy prices? *Journal of Monetary Economics*, *56*(6), 766–779.
Enders, W., & Lee, J. (2012). A unit root test using a Fourier series to approximate smooth breaks. *Oxford Bulletin of Economics and Statistics*, *74*(4), 574–599.
Enilov, M., & Wang, Y. (2022). Tourism and economic growth: Multi-country evidence from mixed-frequency granger causality tests. *Tourism Economics*, *28*(5), 1216–1239.
Ferrara, L., & Marsilli, C. (2019). Nowcasting global economic growth: A factor-augmented mixed-frequency approach. *The World Economy*, *42*(3), 846–875.
Ferraro, D., & Peretto, P. F. (2018). Commodity prices and growth. *The Economic Journal*, *128*(616), 3242–3265.
Ferraro, D., Rogoff, K., & Rossi, B. (2015). Can oil prices forecast exchange rates? An empirical analysis of the relationship between commodity prices and exchange rates. *Journal of International Money and Finance*, *54*, 116–141.
Frankel, J. A. (2010). The natural resource curse: A survey. NBER Working Paper No. 15836.
Gao, L., Hitzemann, S., Shaliastovich, I., & Xu, L. (2022). Oil volatility risk. *Journal of Financial Economics*, *144*(2), 456–491.
Gargano, A., & Timmermann, A. (2014). Forecasting commodity price indexes using macroeconomic and financial predictors. *International Journal of Forecasting*, *30*(3), 825–843.
Garner, C. A. (1989). Commodity prices: Policy target or information variable? *Journal of Money, Credit and Banking*, *21*(4), 508–514.
Ge, Y., & Tang, K. (2020). Commodity prices and GDP growth. *International Review of Financial Analysis*, *71*, 101512.
Ghysels, E. (2016). Macroeconomics and the reality of mixed frequency data. *Journal of Econometrics*, *193*(2), 294–314.
Ghysels, E., Hill, J. B., & Motegi, K. (2016). Testing for granger causality with mixed frequency data. *Journal of Econometrics*, *192*(1), 207–230.
Gokmenoglu, K. K., Bekun, F. V., & Taspinar, N. (2016). Impact of oil dependency on agricultural development in Nigeria. *International Journal of Economic Perspectives*, *10*(2), 151–163.
Gokmenoglu, K. K., Güngör, H., & Bekun, F. V. (2021). Revisiting the linkage between oil and agricultural commodity prices: Panel evidence from an agrarian state. *International Journal of Finance & Economics*, *26*(4), 5610–5620.
Gonçalves, S., & Kilian, L. (2004). Bootstrapping autoregressions with conditional heteroskedasticity of unknown form. *Journal of Econometrics*, *123*(1), 89–120.
Grilli, E. R., & Yang, M. C. (1988). Primary commodity prices, manufactured goods prices, and the terms of trade of developing countries: What the long run shows. *The World Bank Economic Review*, *2*(1), 1–47.
Götz, T. B., Hecq, A., & Smeekes, S. (2016). Testing for granger causality in large mixed-frequency VARs. *Journal of Econometrics*, *193*(2), 418–432.
Hamilton, J. D. (1983). Oil and the macroeconomy since world war II. *Journal of Political Economy*, *91*(2), 228–248.
Hamilton, J. D. (1996). This is what happened to the oil price-macroeconomy relationship. *Journal of Monetary Economics*, *38*(2), 215–220.
Hamilton, J. D. (2003). What is an oil shock? *Journal of Econometrics*, *113*(2), 363–398.
Hamilton, J. D. (2009). Causes and consequences of the oil shock of 2007-08. *Brookings Papers on Economic Activity*, *2009*, 215–284.
Hansen, B. E. (1992). Tests for parameter instability in regressions with I(1) processes. *Journal of Business & Economic Statistics*, *10*(3), 321–335.
Harvey, D. I., Kellard, N. M., Madsen, J. B., & Wohar, M. E. (2017). Long-run commodity prices, economic growth, and interest rates: 17th century to the present day. *World Development*, *89*, 57–70.
Hooker, M. A. (1996). What happened to the oil price-macroeconomy relationship? *Journal of Monetary Economics*, *38*(2), 195–213.
Hooker, M. A. (2002). Are oil shocks inflationary? Asymmetric and nonlinear specifications versus changes in regime. *Journal of Money, Credit and Banking*, *34*(2), 540–561.

IMF. (2019). IMF Primary Commodity Price Index (Base: 2016=100). https://www.imf.org/en/Research/commodity-prices
Jacks, D. S., O'rourke, K. H., & Williamson, J. G. (2011). Commodity price volatility and world market integration since 1700. *Review of Economics and Statistics*, *93*(3), 800–813.
Kilian, L. (2009). Not all oil price shocks are alike: Disentangling demand and supply shocks in the crude oil market. *American Economic Review*, *99*(3), 1053–1069.
Kilian, L., & Park, C. (2009). The impact of oil price shocks on the US stock market. *International Economic Review*, *50*(4), 1267–1287.
Kuzin, V., Marcellino, M., & Schumacher, C. (2011). MIDAS vs. mixed-frequency VAR: Nowcasting GDP in the euro area. *International Journal of Forecasting*, *27*(2), 529–542.
Lee, C. C., & Chang, C. P. (2005). Structural breaks, energy consumption, and economic growth revisited: Evidence from Taiwan. *Energy Economics*, *27*(6), 857–872.
Li, L. (2023). Commodity prices volatility and economic growth: Empirical evidence from natural resources industries of China. *Resources Policy*, *80*, 103152.
Lin, C. F. J., & Teräsvirta, T. (1994). Testing the constancy of regression parameters against continuous structural change. *Journal of Econometrics*, *62*(2), 211–228.
Liu, H., & Song, H. (2018). New evidence of dynamic links between tourism and economic growth based on mixed-frequency granger causality tests. *Journal of Travel Research*, *57*(7), 899–907.
Liu, P., & Tang, K. (2011). The stochastic behavior of commodity prices with heteroskedasticity in the convenience yield. *Journal of Empirical Finance*, *18*(2), 211–224.
Maheu, J. M., Song, Y., & Yang, Q. (2020). Oil price shocks and economic growth: The volatility link. *International Journal of Forecasting*, *36*(2), 570–587.
Makhlouf, Y., Kellard, N. M., & Vinogradov, D. (2017). Child mortality, commodity price volatility and the resource curse. *Social Science & Medicine*, *178*, 144–156.
Marcellino, M. (1999). Some consequences of temporal aggregation in empirical analysis. *Journal of Business & Economic Statistics*, *17*(1), 129–136.
Mendoza, E. G. (1997). Terms-of-trade uncertainty and economic growth. *Journal of Development Economics*, *54*(2), 323–356.
Mohaddes, K., & Raissi, M. (2017). Do sovereign wealth funds dampen the negative effects of commodity price volatility? *Journal of Commodity Markets*, *8*, 18–27.
Narayan, P. K., Sharma, S. S., Poon, W. C., & Westerlund, J. (2014). Do oil prices predict economic growth? *New Global evidence'*, *Energy Economics*, *41*, 137–146.
Nechifor, V., Calzadilla, A., Bleischwitz, R., Winning, M., Tian, X., & Usubiaga, A. (2020). Steel in a circular economy: Global implications of a green shift in China. *World Development*, *127*, 104775
Newey, W. K., & West, K. D. (1987). A simple, positive semi-definite, heteroskedasticity and autocorrelation consistent covariance matrix. *Econometrica*, *55*(3), 703–708.
Newey, W. K., & West, K. D. (1994). Automatic lag selection in covariance matrix estimation. *Review of Economic Studies*, *61*(4), 631–653.
Pan, Z., Wang, Y., Wu, C., & Yin, L. (2017). Oil price volatility and macroeconomic fundamentals: A regime switching GARCH-MIDAS model. *Journal of Empirical Finance*, *43*, 130–142.
Phan, D. H. B., Sharma, S. S., & Narayan, P. K. (2015). Oil price and stock returns of consumers and producers of crude oil. *Journal of International Financial Markets, Institutions and Money*, *34*, 245–262.
Phillips, P. C., & Perron, P. (1988). Testing for a unit root in time series regression. *Biometrika*, *75*(2), 335–346.
Pradhan, R. P., Arvin, M. B., & Ghoshray, A. (2015). The dynamics of economic growth, oil prices, stock market depth, and other macroeconomic variables: Evidence from the G-20 countries. *International Review of Financial Analysis*, *39*, 84–95.
Raddatz, C. (2007). Are external shocks responsible for the instability of output in low-income countries? *Journal of Development Economics*, *84*(1), 155–187.
Rossi, B. (2005). Optimal tests for nested model selection with underlying parameter instability. *Econometric Theory*, *21*(5), 962–990.
Sharma, S. S., Phan, D. H. B., & Iyke, B. (2019). Do oil prices predict Indonesian macroeconomy? *Economic Modelling*, *82*, 2–12.
Stock, J. H., & Watson, M. W. (2003). Forecasting output and inflation: The role of asset prices. *Journal of Economic Literature*, *41*(3), 788–829.
Svensson, L. E. (2005). Oil prices and ECB monetary policy. Committee on Economic and Monetary Affairs, 1–4. https://larseosvensson.se/files/papers/ep501.pdf
Tahar, M. B., Slimane, S. B., & Houfi, M. A. (2021). Commodity prices and economic growth in commodity-dependent countries: New evidence from nonlinear and asymmetric analysis. *Resources Policy*, *72*, 102043.
Tang, K., & Xiong, W. (2012). Index investment and the financialization of commodities. *Financial Analysts Journal*, *68*(6), 54–74.
Troster, V., Shahbaz, M., & Uddin, G. S. (2018). Renewable energy, oil prices, and economic activity: A granger-causality in quantiles analysis. *Energy Economics*, *70*, 440–452.
UN. (2019). *World economic situation and prospects 2019*. United Nations Publications.
UNCTAD. (2013). *Facts and figures on commodities and commodities trade*. https://unctad.org/press-material/facts-and-figures-commodities-and-commodities-trade
UNCTAD. (2021). *State of commodity dependence 2021*. Geneva, Switzerland.
Wang, F., & Liao, H. (2022). Unexpected economic growth and oil price shocks. *Energy Economics*, *116*, 106430.

SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

How to cite this article: Enilov, M. (2023). The predictive power of commodity prices for future economic growth: Evaluating the role of economic development. *International Journal of Finance & Economics*, 1–23. https://doi.org/10.1002/ijfe.2821