



Energy and Bank Equity Interactions

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Oil price shocks harm real output and bank and industrial profit in most oil-importing countries, which has motivated us to investigate the impact of these shocks on the equity performance of banking industries. To fulfill the research objectives, we involve a sample of developed and emerging economies for comparison purposes. The objective of employing the Toda and Yamamoto (Journal of econometrics, 1995, 66 (1), 225–250) causality test is to explore the time-variant relationship between oil prices and banking indices to investigate how oil price shocks affect the performance of country-specific banking industries. In addition, an impulse response function and variance decomposition analysis are utilized to, respectively, examine the time-variant relationship between oil price shocks and macroeconomic factors and the performance of the banking sector. Results vary across different economies in our sample, but the magnitude of oil price impact is relatively significant in the US, the UK, Canada, Japan, Mexico, and Brazil. The findings indicate that oil price rises adversely affect equity bank indices in developed and emerging economics except for Mexico. Notably, our findings show that oil prices and interest rates jointly have significant power in explaining the banking equity variation and suggest that international bank portfolio investors should consider hedging oil price risk.

Keywords: bank indices, oil price shocks, toda-yamamoto causality test, impulse response function, variance decomposition bank indices, variance decomposition JEL classification: Q43, E02, G21

INTRODUCTION

The business connection between the equity market, especially for the banking sector and oil industries, has placed commercial banks in a vulnerable position when facing oil price shocks. Wells Fargo, the third-largest bank in the US, has a total amount of \$ 42 billion exposure to the oil and gas industry in 2016, including a \$ 17.8 billion energy-loan book. In addition, a stress test conducted by Jefferies documents that major European large banks, such as Standard Chartered and HSBC, would take a hit at no less than 1.3 and 1 billion, respectively.¹ In line with Jefferies, Bernstein Research has estimated that the combined losses of Barclays, RBS, HSBC, and Standard Chartered from falling oil prices could amount to \$ 3.4 billion.² Thus, the abovementioned reports explicitly suggest that there is a direct impact of oil price shocks on bank profitability through oil-related loan lending. On the other hand, oil prices impose an indirect influence on the economy. For major emerging oil-exporting countries, plumed oil price hinders fiscal spending, which, in turn, jeopardizes corporate and bank performance. In addition, high oil price motivates the expansion of productive capacity of oil-exporting countries with uprising public and private investment. For oil-importing countries, high oil price potentially enhances the consumer price index followed by potential interest rate

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adjustment, which transmits the impact on the banking industry. These economic phenomena drive our motivation to explore the time-variant relationship between macroeconomic fluctuation, oil price return, and the performance of the banking industry.

Nonetheless, the existing literature focuses on the transitional impact between macroeconomics, oil price fluctuation, and bank index returns. Moreover, a larger body of literature focuses on the linkage between oil prices and macroeconomic factors, which furnish evidence that mainly emphasizes the influence of oil price on macroeconomic changes (e.g., Hamilton, 1983; Burbidge and Harrison, 1984; Gisser and Goodwin, 1986; MA Hooker 1996; Ferderer, 1997; Ciner 2001; Mussa, 2000; Jones et al., 2004).³ Another strand of literature discusses the response of industrial equity return to oil price shocks and shows that the relationship between oil price changes and industrial returns varies across different industries (Huang et al., 1996; Boyer and Filion 2007; McSweeney and Worthington, 2008; Nandha and Faff, 2008). Generally, the findings of this batch of the literature suggest that industries associated with energy are positively sensitive to oil price changes.

Additionally, a considerable thread of literature mainly stresses the influence of macroeconomic uncertainty on bank operations. For example, Baum et al. (2009) and Quagliariello (2009) examine how macroeconomic shocks affect bank signals about expected returns. The main theoretical framework that backs their study argues that macroeconomic uncertainty is the obstacle for banks to foresee further investment opportunities. Additional studies, in a similar vein, reinforce that macroeconomic circumstances impose an impact on the performance of the banking industry (e.g., Salas and Saurina (2002); Qualiariello 2007; Pesola (2001); Bikker and Hu (2012); Laeven and Majnoni (2003); Valckx (2003); Gambera (2000) and Meyer and Yeager (2001); Carruth et al. (2000); Garcia and Calmes (2005).

Overall, the abovementioned literature suggests that the potential linkage between oil price shocks and the performance of the banking sector starts with the macroeconomic recession that generates a negative impact on the banking sector. To our best knowledge, the work of Hesse and Poghosyan (2016) represents the pioneering study that investigates the association between oil prices and bank profitability in major oil-exporting countries in the Middle East and North Africa. They conduct a panel analysis consisting of 145 banks in 11 oil-exporting countries from 1994 to 2008 and conclude that oil price shocks have an indirect effect on bank profitability when country-specific macroeconomic and institutional variables are added to the analysis. In addition, they specifically illustrate that the profitability of investment banks is more sensitive to oil price fluctuation because investment banks benefit the most from the boost in economic activities, such as fee income, the launch of

new investment projects, and their ability to adjust their liquidity positions *via* wholesale funding market. This investigation is motivated by Hesse and Poghosyan (2016) who explored the dynamic relationship between oil price shocks and banking industry performance proxied by banking indices. Nevertheless, there are several puzzling points inspired by Hesse and Poghosyan (2016). First, Hesse and Poghosyan (2016) detect solely the contemporary oil-bank relationship. Still, is it possible that the oil-bank relationship can be time-variant? Second, as previously mentioned, the banking industry can jointly be affected by oil price fluctuation and macroeconomic variation. Therefore, which factor, oil prices or macroeconomic, can better explain the variation of banking equity indices?

To search for the answers of the above-mentioned questions, we utilize the Toda and Yamamoto causality test (TY approach, hereafter) to detect the dynamic association. In our study, we include WTI, Brent and Dubai oil price, macroeconomic factors consisting of industry production, interest rates, and CPI, and banking indices to analyze the time-variant relationship between oil price shocks and country-specific banking industry performance in the US, the UK, Canada, Japan, Mexico, Malaysia, and Brazil. In addition, the TY approach permits the generation of variance decomposition that report the explanatory power of oil price shocks to banking performance. Eventually, we compare the influence of oil price shocks with macroeconomic factors in terms of the relative explanatory power.

Our study contributes to the extant literature on energy economics from at least three perspectives. First, we employ an impulse response function that presents the time-variant response of banking indices to oil price shocks. Results vary in different countries. Interestingly, US banking performance is sensitive to oil price shocks. Additionally, a significant response of the Canadian banking index to oil price shocks is detected. Nevertheless, the time-variant relationship between bank indices and oil price fluctuation is insignificant in Mexico, Malaysia, and Brazil. Overall, to our best knowledge, our study is an attempt to venture into this unexplored area of the time-variant relationship between oil prices and bank performance using variance decomposition analysis. Second, this study investigates the dynamic relationship between banking sector performance to macroeconomic fluctuations. Moreover, interest rate changes, as a *vita* macroeconomic factor, are rarely modeled in bank activities and macroeconomic uncertainty literature. The magnitudes of the response of banking indices to specific macroeconomic factors vary across countries. It is noteworthy to mention that the banking sector is evidenced to be sensitive to interest rate fluctuations in this study.

Attentively, our findings illustrate that Dubai oil shocks have the strongest explanatory power in comparison to WTI and Brent oil prices in the US. Of all the macroeconomic factors, interest rate variation contributes to the highest percentage of the variance of banking performance except for the Brazilian banking sector. The plausible explanation of the contribution of interest rate to bank equity indices is that the liquidity mismatch problem can be worsened by the variation of

³Several studies emphasize on sectoral oil price effects. For example, Keane and Prasad (1996) examine oil effects on industry employment and wages. Davis and Haltwanger (2001) analyze the oil effects on sectoral job creation and destruction. Lee and Ni (2002) analyze the changes in industry demand and supply levels due to shocks in the price of oil.

interest rate risk due to the differential maturities of deposits and loans, which potentially enhances the risk of bank insolvency (Bai et al., 2018). Further findings have suggested that even if the relationship between oil price shocks and banking sector performance is statistically insignificant, oil price shocks capture a reasonably high percentage of banking indices variation in Mexico and Brazil. Hence, our results based on the time-series analysis suggest further exploration in this area, especially in Mexico and Brazil markets.

This study is structured as follows. Section two presents the literature review on oil prices, macroeconomic factors and bank operation's response to oil price shocks. Section three discusses the methodology, data sample, and country selection. Section four illustrates the results of the unit root tests, impulse response function, and variance decomposition. Section five concludes this article.

LITERATURE REVIEW

Literature on Oil Price and Macroeconomic Factors

Hamilton (1983) and Gisser and Goodwin (1986) indicate that oil price shocks have an adverse impact on the macroeconomy and might even be a cause of an economic recession. However, the empirical findings of MA (Hooker, 1996) document that the significance of oil's impact on the economy seems to have dramatically decreased and challenged the theoretical assumptions proposed by Hamilton (1983). On the contrary, several studies empirically support the argument of Hamilton (1983). Ferderer (1997) conclude that oil price volatility, measured by the monthly standard deviation of daily oil prices, helps to forecast aggregate output movements in the U.S. Jones et al. (2004) report that oil price shocks appear to be a major contributor to post-oil-price sock recessions, and the magnitude of the effect that an oil price shock has on GDP is approximately -0.06 in terms of elasticity. In addition to Jones et al. (2004), Mussa (2000) indicate that an increase of \$5 per barrel in the oil price is likely to reduce the level of global output by approximately 25 basis points over the first 4 years, which supports the detrimental impact of oil price on the global economy.

Literature on Oil Price and Industrial Equity Returns⁴

Huang et al. (1996) utilize the relationship between the daily U.S. stock returns and oil-futures returns and find evidence that oil-futures returns positively lead individual oil company and petroleum industry stock returns but do not have much influence on other industry indices or the aggregate S&P 500 index. Faff and Brailsford (1999) examine the sensitivity of the

Australian industry equity returns to oil price changes and suggest that oil is an important factor in the industry-based return generating process in Australia and that the direction and magnitude of oil shock sensitivity are of an industry-specific nature. Boyer and Filion (2007) analyze the sensitivity of Canadian oil and gas companies to market-based factors, namely, market return, interest rates, the exchange rate, oil prices and natural gas prices, and fundamental factors, including fluctuations in proven reserves, the volume of production, debt level, operational cash flows, and drilling success. The authors find that market return, appreciation of crude oil, and natural gas prices are positively associated with Canadian oil and gas company stock returns, while interest rates, production volume, and depreciation of Canadian dollar against US dollar are negatively related to stock returns. Nandha and Faff (2008) analyze 35 DataStream global industry indices from 1983 to 2005 and indicate that oil price rises hurt equity returns for all sectors except mining and oil and gas industries. In addition, they detected little evidence of any asymmetry in the oil price sensitivities. McSweeney and Worthington (2008) also examine the impact of oil prices along with other macroeconomic variables on the Australian monthly stock returns. The authors find a negative effect of oil prices on equity returns of banking, retail, and transportation sectors but a positive effect on the energy sector. The authors find no impact on diversified financial, insurance, materials, media, and property trust sectors.

A more recent literature studies the relationship between oil price volatility and industry return fluctuation. Hammoudeh et al. (2004) employ univariate and multivariate GARCH to examine volatility persistence in the crude oil market and its effect on the equity return volatility of the S&P oil sector indices. Their findings document that oil volatility fluctuations have a volatility-echoing effect on the stocks of the companies engaged in oil exploration and production and domestic integrated oil companies while exerting a volatility-dampening effect on the stocks of the oil and gas refining and marketing companies and integrated multinational oil companies. Maghyreh et al. (2016) employ the concept of implied oil price volatility to study the oil-equity relationship and discover a bi-directional volatility spillover between oil prices and equity indices. Wang and Wang, (2019) mainly focus on the case of China and detect frequency dynamics of volatility spillovers between crude oil prices and Chinese equity markets. Their study, using generalized forecast error variance decomposition, reveals that the spillover during China's 2015 financial crisis is negative and attributable to long-term components. In addition, their findings uncover the impact of structural breaks on the analytical results.

Literatures on Bank Performance and Macroeconomic Conditions

There is a large body of literature on how the macroeconomy affects the asset quality of banks. Sala and Saurina (2002) explored the quick transmission of macroeconomic influence to balance sheets in Spanish commercial banks. Financial intermediaries

⁴There are extensive literatures on the interaction between oil price and stock market performance. This section mainly selects the studies on how oil prices influence the industrial equity returns

tend to enhance their lending with relatively lenient selection criteria during economic prosperity. Nevertheless, a high amount of bad loans has made banks suffer losses during the following economic downturns. In addition to Sala and Saurina (2002), Quagliariello (2007) depicts the remarkably increased loan loss provisions and bad debts during economic recessions. Pesola (2001) points out that the sharp fall of GDP growth beneath the forecast level and severe corporate and household indebtedness jointly contribute to the banking crisis in Nordic countries. Another strand of literature, such as Baum et al. (2009) and Quagliariello (2007), analyzes how banks react to macroeconomic uncertainty from the perspective of investment decisions. Baum et al. (2009) employ a portfolio model and suggest that when macroeconomic uncertainty, proxied by the conditional variance of a relevant macroeconomic variable, increases, the cross-bank dispersion of share of risky loans to total assets diminishes, as uncertainty hinders banks' ability to foresee investment opportunities. Similarly, Quagliariello (2009) concludes that banks' ability to accurately forecast future returns is hindered and herding behavior tends to emerge, as witnessed by the reduction of the cross-sectional variance of the share of loans held in a portfolio. Calmès and Théoret (2014) present similar findings and conclude that banks tend to behave more homogeneously in face of macroeconomic uncertainty specifically in the cross-sectional dispersion of loans-to-assets and the cross-sectional dispersion of the non-interest income. The authors also conclude that resilience of the banking system positions at its lowest during the financial crisis.

METHODOLOGY, DATA, AND COUNTRY SELECTION

Toda and Yamamoto Causality Test

In this study, we employ a VAR-based causality test, namely, Toda and Yamamoto (1995) causality test, because it permits the production of dynamic influence from oil price shocks to banking indices fluctuations as well as variance decomposition to present the explanatory power of participated variables. It is worth noting that Granger causality tests are the most common approach to examine the time-series causal relationship between energy issues (i.e., energy price shocks, energy demand, and consumption) and economic activities, such as economic growth, stock market reaction (i.e., Lee, 2005; Lee and Chang 2008; Apergis and Payne 2009; Bruns and Gross, 2013; Doğrul and Soytas, 2010; Le and Chang, 2015; Nazlioglu and Soytas, 2011). Noticeably, the accuracy of the information on the order of integration and cointegration critically determines the results of Granger causality tests (Johansen 1988 and 1991). Nevertheless, unit root and cointegration tests tend to have low power, potentially leading to the pretesting bias (Toda and Yamamoto, 1995). Thus, Toda and Yamamoto (1995) have developed a new approach for causality test that avoids the problem associated with the common Granger causality test by ignoring the inevitable non-stationary property or cointegration between the series (Mavrotas and Kelly, 2001;

Wolde-Rufael, 2005). To undertake the TY approach, the VAR-based model is presented as follows:

$$BP_t = \alpha_0 + \sum_{i=1}^k \alpha_{1i} BP_{t-i} + \sum_{j=k+1}^{dmax} \alpha_{2j} BP_{t-j} + \sum_{i=1}^k \theta_{1i} EV_{t-i} + \sum_{j=k+1}^{k+dmax} \theta_{2j} EV_{t-j} + \varepsilon_{1t}, \quad (1)$$

$$EV_t = \beta_0 + \sum_{i=1}^k \beta_{1i} EV_{t-i} + \sum_{j=k+1}^{dmax} \beta_{2j} EV_{t-j} + \sum_{i=1}^k \vartheta_{1i} BP_{t-i} + \sum_{j=k+1}^{K+dmax} \theta_{2j} BP_{t-j} + \varepsilon_{1t}, \quad (2)$$

where BP refers to the performance of the banking sector, represented as the logarithm value of country-specific banking indices. EV represents a set of explanatory variables. The crucial aspect of the TY procedure is to determine the optimal lag order (k). To achieve this goal, we follow Hasanov et al. (2016) to utilize four information criteria, namely, final prediction error (FPE), Akaike Information Criterion (AIC), Schwartz criterion (SC), and Hannan-Quinn (HQ). However, in reality, a different criterion suggests different optimal lag orders. Thus, autocorrelation LM tests are employed to determine the optimal lag orders.⁵ In addition to autocorrelation LM tests, Wald joint tests identify the VAR coefficients' joint significance.

Before the commencement of causality testing among the involved data series, it is important to identify the order of integration referring to the augmented lag length in the VAR system. In our study, we follow Hasanov et al. (2016) to determine the augmented lag order ($dmax$) to be one.

Data

The research objectives, as previously mentioned, request the oil price series and the data of macroeconomic indicators from January 1995 to March 2021, except for Malaysia.⁶ Oil price series are composed of WTI, Brent, and Dubai oil prices by following the prior literature and is collected from FRED Economic Data (Federal Reserve Bank of St. Louis). Macroeconomic factors contain interest rates, industrial production, and CPI. Interest rates are defined as the short-term discount rate series (EM. Diaz et al., 2016). In addition, short-interest rates are considered by other studies such as Cunado and Perez de Gracia (2014). Industry production has been used as a proxy to measure the magnitude of economic activities. The total industrial production index measures the real production output of manufacturing, mining, and electric and gas utilities industries (EM. Diaz et al., 2016). In addition to interest rates and industrial production, CPI is employed to measure the country-specific status of inflation. Macroeconomic data is obtained from International Financial Statistics (International

⁵Autocorrelation LM tests need to be statistically insignificant before the finalization of optimal lag orders. In our studies, all the selected lag orders sufficiently satisfied with autocorrelation requirements

⁶It is worth noting that the sample period ends at March 2019 due to the data limits

TABLE 1 | Energy intensity and crude oil consumption, production, and trade balance at selected countries.

Panel A: Energy intensity to GDP									
Country	2007	2008	2009	2010	2011	2012	2013	2014	2015
US	0.171	0.167	0.163	0.163	0.159	0.151	0.152	0.150	0.145
United Kingdom	0.096	0.094	0.093	0.094	0.086	0.088	0.086	0.077	0.076
Canada	0.220	0.215	0.209	0.203	0.202	0.195	0.192	0.190	0.184
Japan	0.127	0.124	0.125	0.126	0.117	0.113	0.112	0.109	0.106
Mexico	0.122	0.124	0.126	0.121	0.121	0.120	0.121	0.116	0.112
Malaysia	0.160	0.160	0.154	0.147	0.145	0.140	0.150	0.146	0.137
Brazil	0.109	0.109	0.106	0.109	0.108	0.112	0.113	0.117	0.119
Panel B: Crude oil consumption (Metric ton)									
Country	2007	2008	2009	2010	2011	2012	2013	2014	2015
US	828	824	782	794	801	788	807	834	846
United Kingdom	81	81	75	74	75	71	65	61	61
Canada	100	96	93	95	90	93	91	91	92
Japan	205	195	182	180	171	170	173	164	163
Mexico	72	71	71	66	66	67	70	66	61
Malaysia	26	26	26	22	24	27	26	26	27
Brazil	93	94	95	95	97	102	109	111	105
Panel C: Crude oil production (Metric ton)									
Country	2007	2008	2009	2010	2011	2012	2013	2014	2015
US	304	299	322	333	346	391	455	512	555
United Kingdom	77	72	68	63	52	45	41	40	45
Canada	154	152	150	158	167	180	191	208	214
Japan	1	1	1	1	1	1	1	0	0
Mexico	173	157	146	145	143	143	141	136	127
Malaysia	35	35	33	34	30	31	29	31	33
Brazil	92	96	102	107	111	111	108	120	129
Panel D: Crude oil balance of trade (Metric ton)									
Country	2007	2008	2009	2010	2011	2012	2013	2014	2015
US	519	506	452	449	420	356	290	242	215
United Kingdom	6	12	9	13	24	29	25	22	16
Canada	-55	-58	-59	-64	-80	-86	-100	-116	-124
Japan	206	199	179	181	177	179	178	166	162
Mexico	-89	-74	-65	-71	-70	-66	-62	-60	-62
Malaysia	-7	-6	-6	-9	-2	-2	-1	-1	-5
Brazil	93	94	95	95	97	102	109	111	105

Source: Global Energy Statistical Year Book 2016.

Monetary Fund). Note that the series of macroeconomic indicators are in the monthly frequency, whereas the oil price series are presented daily. To guarantee the consistency of frequency for the analytical purpose, we convert the oil price series by calculating the average value of the daily oil prices and then transform the monthly oil price series into logarithm values, which is consistent with the prior studies, such as Ratti and Vespignani (2016).

Country Selection

The country selection of this study serves two dimensions: (1) oil-exporting developed countries vs oil-importing countries and (2) oil-exporting developed countries vs oil-exporting emerging countries. The first dimension is designed because oil price shocks impose different magnitudes of impact on the domestic equity markets as well as trade balances, which, in turn, has the differential spillover influence on the macroeconomy (Rafiq et al., 2016). Hence, we select Canada as the oil-exporting developed country, whereas the US, the UK, and Japan are oil-importing

developed countries. As for the second dimension, oil price shocks might have a heterogeneous influence on the unemployment rate of developed and emerging countries, which, in turn, affects the economic growth as the driver of the banking equity (Doğrul and Soytaş, 2010). According to the prior studies, Malaysia, Mexico, and Brazil are selected (Kuboniwa, 2014; Sharma and Gulati, 2015; Boubaker et al., 2016; de Oliveira et al., 2019). In addition, **Table 1** presents energy intensity to GDP, crude oil consumption, production, and trade balance throughout 2007 to 2015. All the statistics are collected from the Global Energy Statistical Year Book 2016. Energy intensity to GDP refers to energy per unit divided by GDP per unit, suggesting the contribution of energy to GDP growth. In Panel A, Canada has the highest value of energy intensity to GDP, implying the high economic dependence on energy. It is noteworthy that the breakthrough of shale-oil technology causes a dramatic growth of oil production in the US and shrinkage of oil-importing, suggesting that the US is less dependent on overseas oil supply. In contrast, the

TABLE 2 | Descriptive statistics.

	Mean	Median	Std.Dev	Skewness	Kurtosis	Observation
Panel A: US						
Bank index	2.573	2.62	0.158	-0.733	2.646	315
WTI oil	1.653	1.697	0.259	-0.294	2.024	315
Brent oil	1.655	1.711	0.286	-0.304	2.024	315
Dubai oil	1.634	1.701	0.29	-0.27	1.934	315
CPI	1.971	1.986	0.072	-0.246	1.747	315
Industry production	1.97	1.978	0.039	-1.233	4.053	315
Interest rate	2.4	1.73	2.243	0.449	1.566	315
Panel B: United Kingdom						
Bank index	2.873	2.845	0.151	0.101	2.082	315
WTI oil	1.653	1.697	0.259	-0.294	2.024	315
Brent oil	1.655	1.711	0.286	-0.304	2.024	315
Dubai oil	1.634	1.701	0.29	-0.27	1.934	315
CPI	1.934	1.929	0.067	0.039	1.615	315
Industry production	2.017	2.018	0.019	-1.574	10.258	315
Interest rate	3.839	4.285	2.08	0.19	2.352	315
Panel C: Canada						
Bank index	2.859	2.937	0.279	-0.712	2.755	315
WTI oil	1.653	1.697	0.259	-0.294	2.024	315
Brent oil	1.655	1.711	0.286	-0.304	2.024	315
Dubai oil	1.634	1.701	0.29	-0.27	1.934	315
CPI	1.945	1.951	0.29	-0.27	1.934	315
Industry production	1.977	1.982	0.039	-0.637	3.052	315
Interest rate	3.772	3.76	1.93	0.341	2.309	315
Panel D: Japan						
Bank index	1.496	1.419	0.259	0.526	2.234	315
WTI oil	1.653	1.697	0.259	-0.294	2.024	315
Brent oil	1.655	1.711	0.286	-0.304	2.024	315
Dubai oil	1.634	1.701	0.29	-0.27	1.934	315
CPI	1.994	1.991	0.008	0.397	1.938	315
Industry production	2.011	2.008	0.028	-0.544	5.502	315
Interest rate	1.174	1.258	0.893	0.617	3.5	315
Panel E: Mexico						
Bank index	4.77	5.047	0.621	-0.598	1.919	315
WTI oil	1.653	1.697	0.259	-0.294	2.024	315
Brent oil	1.655	1.711	0.286	-0.304	2.024	315
Dubai oil	1.634	1.701	0.29	-0.27	1.934	315
CPI	1.921	1.951	0.188	-0.942	3.455	315
Industry production	1.952	1.963	0.047	-1.375	4.892	315
Interest rate	11.866	7.7	12.059	2.878	13.904	315
Panel F: Malaysia						
Bank index	2.66	2.653	0.246	-0.763	3.222	291
WTI oil	1.651	1.693	0.266	-0.263	1.915	291
Brent oil	1.651	1.706	0.295	-0.258	1.911	291
Dubai oil	1.628	1.678	0.3	-0.215	1.825	291
CPI	1.967	1.965	0.072	0.022	1.855	291
Industry production	1.972	2.006	0.108	-0.627	2.409	291
Interest rate	3.647	2.99	1.736	2.233	7.604	291
Panel G: Brazil						
Bank index	3.346	3.58	0.486	-0.469	1.771	315
WTI oil	1.653	1.697	0.259	-0.294	2.024	315
Brent oil	1.655	1.711	0.286	-0.304	2.024	315
Dubai oil	1.634	1.701	0.29	-0.27	1.934	315
CPI	1.938	1.947	0.203	-0.163	1.857	315
Industry production	1.976	1.982	0.055	-0.243	1.99	315
Interest rate	16.241	13.9	10.757	2.073	8.638	315

All the values are transformed to logarithm forms except interest rates.

TABLE 3 | Unit root test results.

	ADF test				PP tests			
	Level		First difference		Level		First difference	
	(i)	(ii)	(i)	(ii)	(i)	(ii)	(i)	(ii)
Interest rates								
US	-1.758	-2.038	-8.951***	-8.952***	-1.642	-2.253	-9.36***	-9.356***
United Kingdom	-1.817	-3.56**	13.486***	-13.5***	-1.831	-2.952	-13.233***	-13.241***
Canada	-2.575*	-4.117***	-15.045***	-15.105***	-2.566	-3.994***	-14.859***	-14.925***
Japan	-2.498	-4.545***	-13.258***	-13.284***	-3.877***	-5.005***	-14.174***	-14.425***
Malaysia	-1.925	-2.052	-27.809***	-27.766***	-2.286	-2.68	-26.874***	-26.84***
Mexico	-3.978***	-3.805**	-25.096***	-25.699***	-2.819*	3.247*	-17.401***	-24.335***
Brazil	-5.184***	-6.355***	-6.036***	-6.067***	-3.047**	-4.042***	-13.661***	-13.648***
CPI								
US	-1.16	-2.04	-8.951***	8.952***	-1.642	-2.253	-9.359***	-9.356***
United Kingdom	-0.189	-2.7	-2.731*	-2.71	-0.707	-1.737	-18.574***	-18.551***
Canada	-0.638	-2.629	-16.879***	-16.862***	-0.772	-2.217	-18.263***	-18.357***
Japan	-1.964	-2.137	-3.473***	-3.449***	-1.137	-1.467	-14.077***	-14.058***
Malaysia	-0.908	-3.418**	-12.747***	-12.75***	-1.174	-3.078	-12.265***	-12.255***
Mexico	-1.645	-3.794**	-8.169***	-7.321***	-8.708***	-17.22***	-5.637***	-6.264***
Brazil	-2.311	-3.584**	-7.795***	-8.079***	-2.751**	-3.473**	-7.649***	-8.045***
Industry production								
US	-3.062**	-2.691	-12.95***	-13.104***	-2.935**	-2.642	-14.294***	-14.466***
United Kingdom	-2.785*	-4.21***	-13.414***	-13.408***	-2.849*	-4.5***	-19.635***	-20.016***
Canada	-1.977	-2.296	-16.076***	-16.07***	-1.977	-2.352	-16.084***	-16.079***
Japan	-3.562***	-3.71***	-14.882***	-14.858***	-3.449**	-3.608**	14.867***	-14.842***
Malaysia	-1.722	-2.638	-4.36***	-4.45***	-1.876	-5.171***	-34.468***	-34.935***
Mexico	-3.243**	-3.514**	-15.48***	-15.571***	-2.953**	-3.085	-16.374***	-17.863***
Brazil	-1.98	-2.127	-18.176***	-18.164***	-1.694	-1.777	-19.135***	-19.251***
WTI Oil								
US	-2.223	-2.609	-13.529***	-13.518***	-1.943	-2.204	-13.074***	-13.055***
United Kingdom	-2.223	-2.609	-13.529***	-13.518***	-1.943	-2.204	-13.074***	-13.055***
Canada	-2.223	-2.609	-13.529***	-13.518***	-1.943	-2.204	-13.074***	-13.055***
Japan	-2.223	-2.609	-13.529***	-13.518***	-1.943	-2.204	-13.074***	-13.055***
Malaysia	-1.823	-2.252	-12.91***	-12.9***	-1.653	-2.003	-12.903***	-12.89***
Mexico	-2.223	-2.609	-13.529***	-13.518***	-1.943	-2.204	-13.074***	-13.055***
Brazil	-2.223	-2.609	-13.529***	-13.518***	-1.943	-2.204	-13.074***	-13.055***
Brent oil								
US	-1.996	-2.348	-13.478***	-13.471***	-1.815	-2.069	-13.113***	-13.095***
United Kingdom	-1.996	-2.348	-13.478***	-13.471***	-1.815	-2.069	-13.113***	-13.095***
Canada	-1.996	-2.348	-13.478***	-13.471***	-1.815	-2.069	-13.113***	-13.095***
Japan	-1.996	-2.348	-13.478***	-13.471***	-1.815	-2.069	-13.113***	-13.095***
Malaysia	-1.669	-2.11	-13.61***	-13.599***	-1.599	-1.967	-13.615***	-13.589***
Mexico	-1.996	-2.348	-13.478***	-13.471***	-1.815	-2.069	-13.113***	-13.095***
Brazil	-1.996	-2.348	-13.478***	-13.471***	-1.815	-2.069	-13.113***	-13.095***
Dubai oil								
US	-2.006	-2.438	-12.462***	-12.455***	-1.737	-2.017	-11.836***	-11.812***
United Kingdom	-2.006	-2.438	-12.462***	-12.455***	-1.737	-2.017	-11.836***	-11.812***
Canada	-2.006	-2.438	-12.462***	-12.455***	-1.737	-2.017	-11.836***	-11.812***
Japan	-2.006	-2.438	-12.462***	-12.455***	-1.737	-2.017	-11.836***	-11.812***
Malaysia	-1.666	-2.246	-12.334***	-12.321***	-1.463	-1.543	-12.241***	-12.139***
Mexico	-2.006	-2.438	-12.462***	-12.455***	-1.737	-2.017	-11.836***	-11.812***
Brazil	-2.006	-2.438	-12.462***	-12.455***	-1.737	-2.017	-11.836***	-11.812***
Bank indices								
US	-2.66*	-2.627	-13.205***	-13.194***	-2.676*	-2.609	-13.15***	-13.139***
United Kingdom	-2.494	-2.957	-12.435***	-12.484***	-2.313	-2.752	-12.317***	-12.329***
Canada	-2.055	-3.302	-13.068***	-13.112***	-2.258	-2.931	-13.007***	-13.027***
Japan	-2.077	-2.298	-13.31***	-13.327***	-2.028	-2.217	-13.238***	-13.252***
Malaysia	-1.952	-4.741***	-11.342***	-11.322***	-1.508	-2.88	-11.236***	-11.216***
Mexico	-2.353	-1.656	-14.595***	-14.775***	-1.606	-1.309	-13.557***	-13.669***
Brazil	-1.888	-2.101	-13.608***	-13.687***	-1.767	-1.871	-14.108***	-14.273***

(i) refers to constant, (ii) refers to constant and linear trend. ***, **, and *, respectively, represent the significant level of 1, 5, and 10%.

TABLE 4 | Causality test.

Country	From	To	Test statistic	p-value
US	WTI oil	Bank index	8.313	0.04
	Brent oil		0.85	0.8374
	Dubai oil		2.288	0.5148
	CPI		7.273	0.064
	Interest rate		10.023	0.018
	Industry production		0.52	0.92
United Kingdom	WTI oil		1.7	0.427
	Brent oil		0.334	0.846
	Dubai oil		0.663	0.718
	CPI		3.404	0.183
	Interest rate		0.343	0.842
	Industry production		2.652	0.266
Canada	WTI oil		3.111	0.211
	Brent oil		0.726	0.696
	Dubai oil		1.534	0.465
	CPI		1.083	0.582
	Interest rate		1.89	0.389
	Industry production		0.597	0.742
Japan	WTI oil		1.373	0.503
	Brent oil		0.674	0.714
	Dubai oil		4.792	0.0091
	CPI		6.082	0.048
	Interest rate		22.384	0.000
	Industry production		8.135	0.017
Mexico	WTI oil		11.913	0.535
	Brent oil		19.075	0.121
	Dubai oil		26.579	0.014
	CPI		15.408	0.283
	Interest rate		10.094	0.686
	Industry production		13.142	0.437
Malaysia	WTI oil		7.322	0.502
	Brent oil		12.583	0.127
	Dubai oil		13.975	0.082
	CPI		2.298	0.971
	Interest rate		57.93	0.000
	Industry production		8.268	0.408
Brazil	WTI oil		1.943	0.857
	Brent oil		4.664	0.458
	Dubai oil		5.666	0.34
	CPI		6.867	0.231
	Interest rate		15.668	0.008
	Industry production		8.338	0.139

United Kingdom has the lowest energy intensity to GDP. Panels B and C, respectively, depict crude oil consumption and production. The US is ranked the highest in the terms of both crude oil consumption and production. This may explain why most of the past literature tends to focus on the US for energy economic studies. In addition, Canada is commonly deemed as one of the important oil-dependent countries. Panels C and D illustrate the annual growth of oil production and oil-importing. Mexico is rarely included in the previous studies on energy economics. Nevertheless, Mexico has the third-largest crude oil production according to Panel C. Japan is an important oil-importing country as shown in Panel D. According to the statement of Le and Chang (2015), Malaysia is an energy-exporting country with 28.8% export dependence on oil and 86% export dependence on gas, which generates a substantial foreign exchange. As the third-largest energy intensity to GDP further explains the contribution of the energy sector to the

domestic economy in Malaysia, however, the oil-exporting amount in Malaysia is obviously below Canada and Mexico.

RESULTS

Descriptive Statistics

Table 2 depicts the summary statistics of all the variables across all the involved countries. All the variables are normally distributed according to Jarque–Bera tests. It is noteworthy that Mexico and Brazil have experienced a period when the interest rate is high in the early stage of the timespan between 1995 and 2021 (except for Malaysia). In addition to the descriptive statistics, the analytical process consists of a unit root test, causality test, impulse function analysis, and variance decomposition analysis.⁷

Unit Root Test

We follow prior studies to utilize two major unit root tests, namely, the Augmented Dickey and Fuller (1981) (ADF) test and Phillips and Perron (1988) (PP) test. The null of ADF and PP suggests the stationary characteristic of specific variables. Table 3 illustrates the results of ADF and PP unit root tests. All the first difference variables are statistically stationary, except CPI of the United Kingdom.

Toda and Yamamoto Causality Test

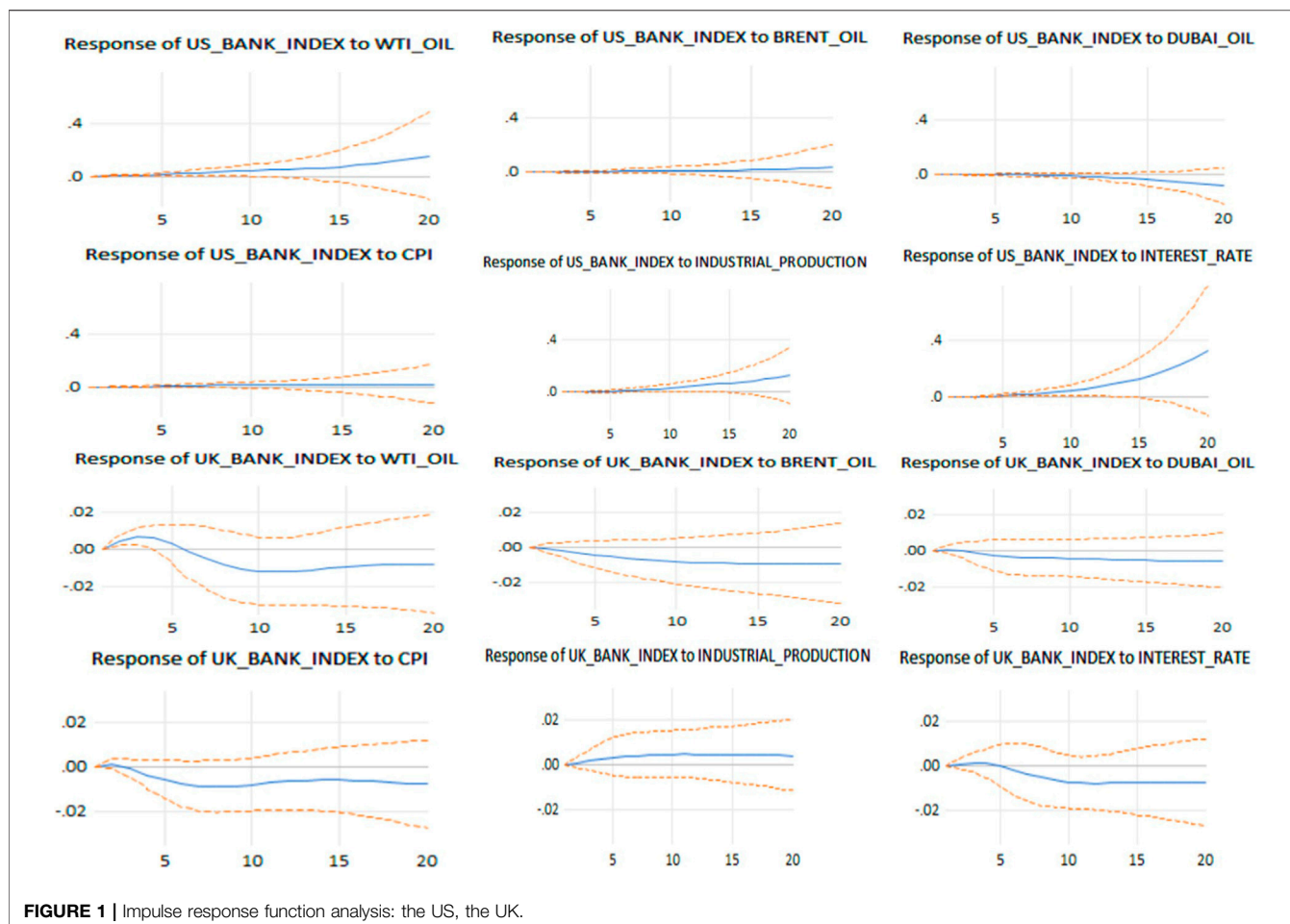
Inspired by the study of Pal and Mitra (2017), the TY-based causality test allows us to explore the long-run causal relationship between oil price shocks, the performance of the banking sector, and macroeconomic variables. All the test results are presented in Table 4. Causal associations from oil price shocks are statistically verified in the US, Japan, and Mexico. It is hardly surprising that the high energy intensity, oil production in the US contributes to a significant causal effect. Japan is highly dependent on oil imports, which explains the causality between oil prices and the bank index. Besides oil price fluctuation, interest rates, as the important macroeconomic indicator, impose a significant influence on banking performance in the US, Japan, Malaysia, and Mexico. It is noteworthy that all the variables related to oil price shocks have a causal impact on banking sector performance in the US.

Impulse Response Function Analysis

Hasanov et al. (2016) explicitly state that the TY approach generates an impulse response function that permits us to observe the dynamic relationship to present deeper empirical insights.⁸ Empirically, the results illustrated by Figures 1–4, to some extent, reinforce the results based on TY analysis. Banking performance significantly reacts to oil price shocks in the United Kingdom, Canada, Japan, Mexico, and Brazil in

⁷We employ the Johansen and Juselius (1990) cointegration test to detect the cointegrating relationship between country-specific variables. However, only the variables in Mexico are cointegrated at one vector

⁸Generalized impulse function is used in this study and it produces similar results

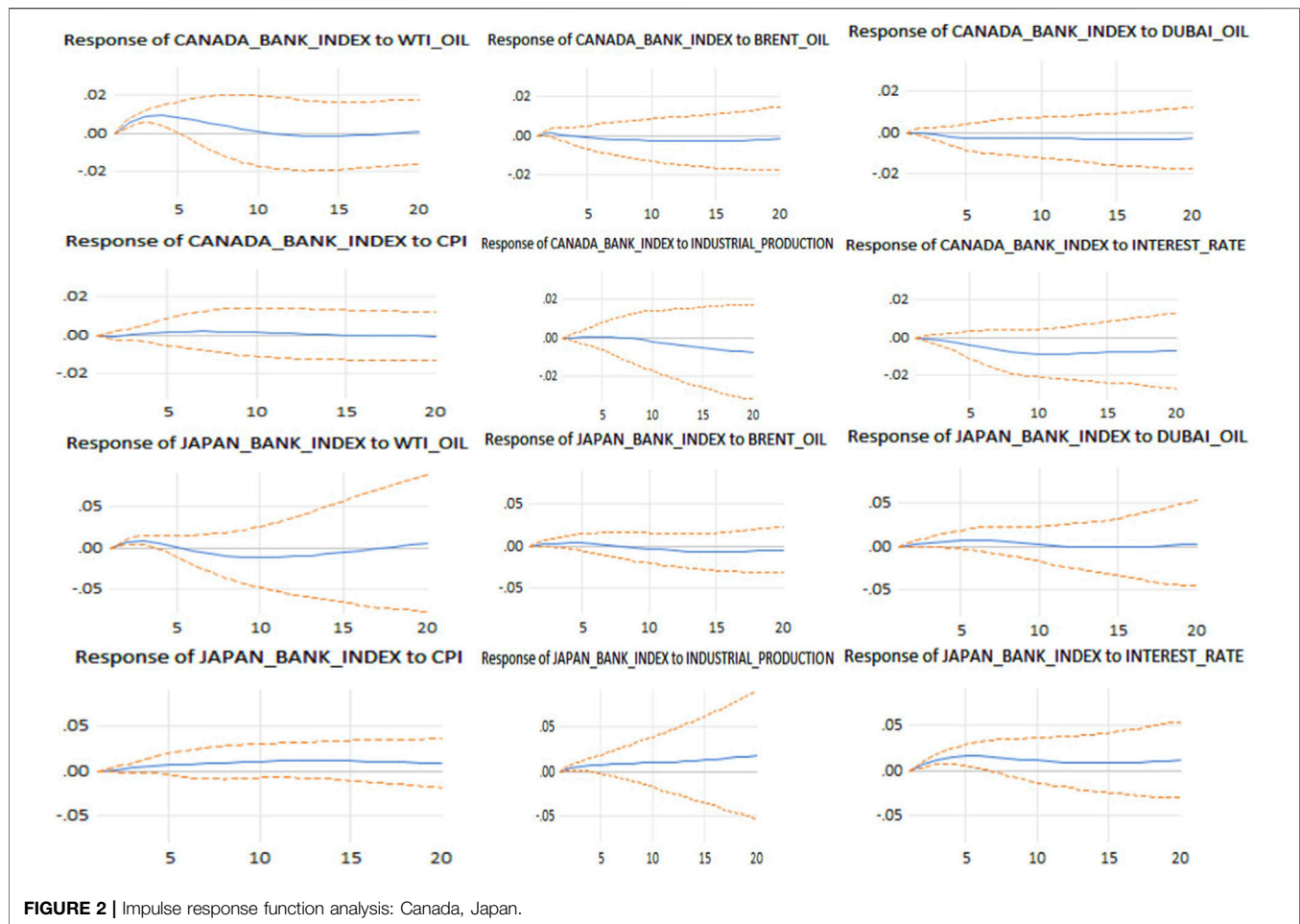


the beginning of the period span. Noticeably, the positive reaction of banking indices in Malaysia to WTI oil price shocks comes across the entire period at an insignificant statistical level. Regarding the dynamic response of banking sector performance to macroeconomic variables, the banking industry in the US and the UK are exposed to a significant influence of all macroeconomic variables. Canadian banks are relatively vulnerable to industry production shocks. Japanese banks are significantly associated with the changes in interest rates. Industry production and interest rate fluctuation impose a significant impact on the Brazilian banking industry. Overall, our empirical findings support Quagliariello, M (2009) and Calmès and Théoret (2014) who argue that the banking operations are more sensitive to macroeconomic changes. In addition, we find out oil price shocks potentially influence banking sector performance in the United Kingdom, Canada, Japan, Mexico, and Brazil.

Variance Decomposition Analysis

As presented by Brahmasrene et al. (2014), the TY approach also produces variance decomposition of all the involved variables. Variance decomposition, presented in **Table 5**, shows the comparison of explanatory power between oil price shocks and macroeconomic changes. It is noteworthy

that the properties of findings related to variance decomposition analysis are slightly different from the results in previous sections. Observed from the findings of Panel A, WTI oil prices contribute to the largest proportion of the variations of the US bank index during the early stage of the period. Nevertheless, the power of interest rates in explaining the bank performance of the US exceeds the explanatory power of WTI oil prices in the late period. Similar findings are also shown in other countries including Canada and Brazil. Moreover, the variations of interest rates also substantially explain the country-level performance of the banking industry in the US, Canada, Malaysia, and Brazil. It is interesting to note that Dubai oil shocks reasonably contribute to the banking industry of Malaysia. The plausible explanation is that Dubai oil is the benchmark to price the oil products extracted in UAE and exported to Asia, which imposes an impact on pricing the oil products in Asia. It is interesting to note that Brent has less power in explaining the variation of the UK banking industry because the Brent price benchmark is extensively applied in Europe including the UK. Overall, in the cases of the US, UK, Canada, Malaysia, and Brazil, the oil prices, as well as interest rates, are jointly the most important factors that affect the country-level banking industry.



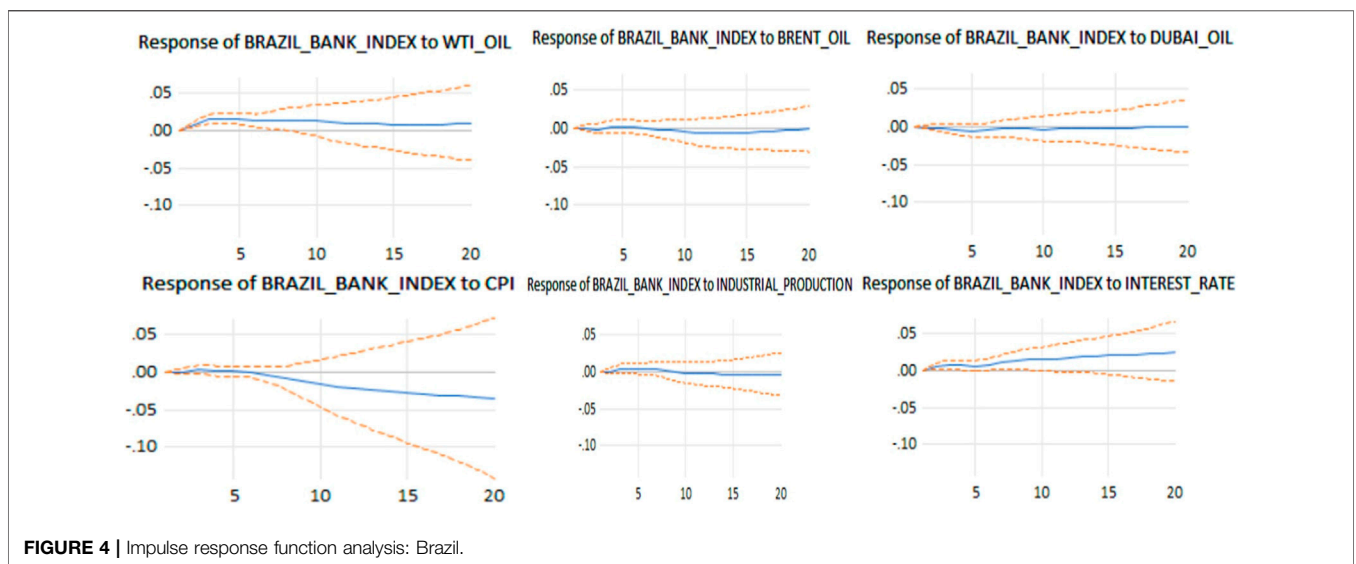
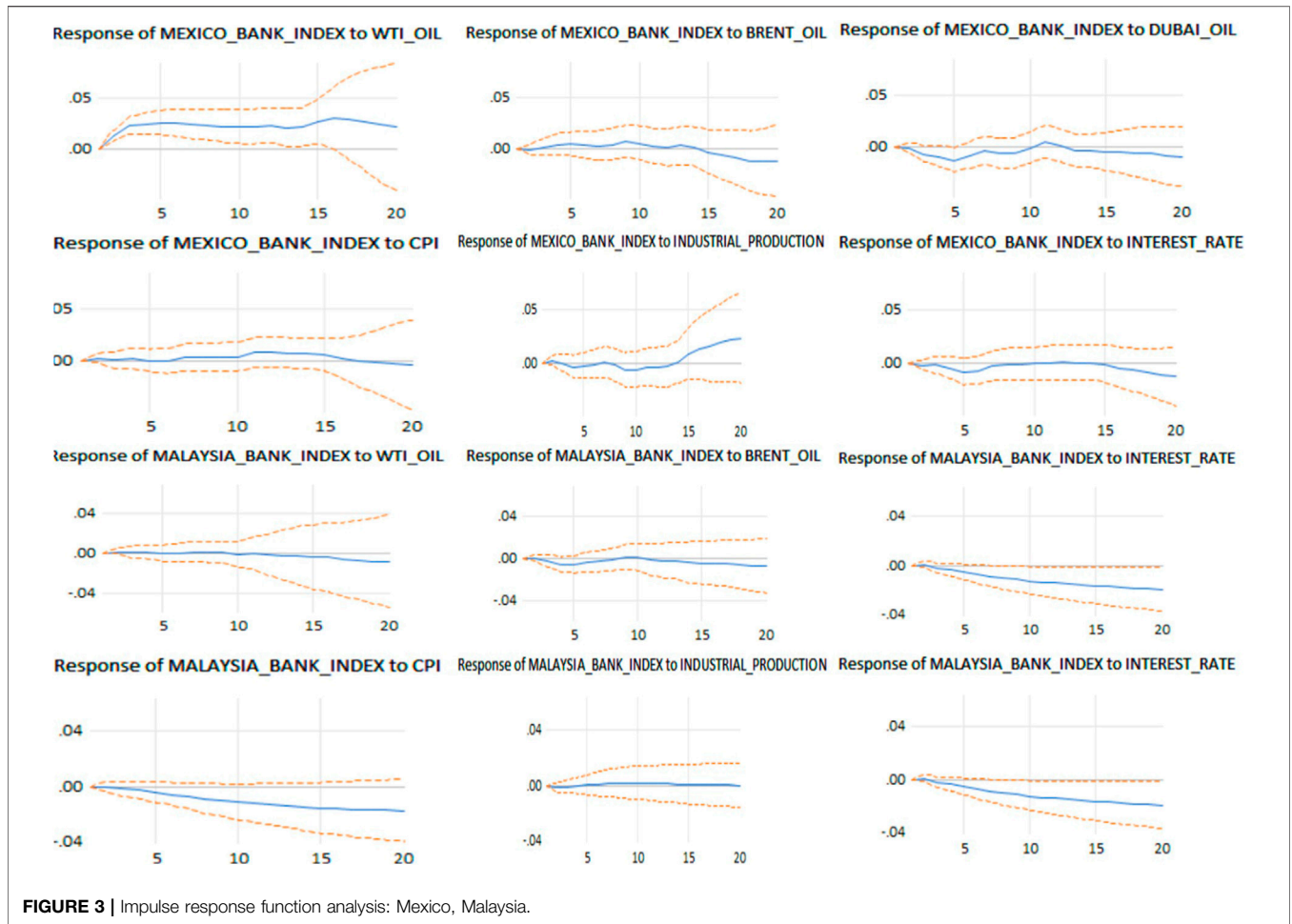
CONCLUSION

In this study, we attempt to explore the dynamic relationship between oil price shocks, macroeconomic changes, and banking sector performance utilizing a dataset from February 1995 to March 2021 (except for Malaysia). Three oil price variables consisting of WTI, Brent, and Dubai oil are employed. To investigate the explanatory power of oil price on banking indices, macroeconomic factors including CPI, interest rates, and industrial production are utilized. This study adopts two recent procedures, namely, unit root tests including the Augmented Dickey and Fuller (1981) (ADF) test and Phillips and Perron (1988) (PP) test. This investigation also uses the Toda and Yamamoto (1995) causality that reports long-term causal relationships, a time-variant association based on impulse response function, and variance decomposition. Three important emerging oil-dependent and exporting countries are included in this study. In addition, the study cover group of developed countries for discussion and comparison purposes, namely, Canada, the US, and Japan.

Empirical findings based on the impulse response function suggest that oil price shocks impose a significant influence on the banking sector in both important oil-consumption and exporting countries such as the US, Canada, and Japan, which is confirmed

by the results on the long-term causal relationship based on the TY approach. Such empirical findings suggest the magnitude of reliance on oil production, exporting, and consumption. These findings potentially make the banking industry sensitive to oil price shocks. On the other hand, our results document that banking indices fluctuation is sensitive to macroeconomic factors, such as interest rate in all countries except Mexico, which confirms early findings by Quagliarillo, M (2009) and Calmès and Théoret (2014).

Our results show that variance decomposition analysis presents results that are somewhat different from the causality test as well as impulse response function. Our interpretation of these slight discrepancies is that oil price shocks capture a relatively high percentage of bank indices variation even if an insignificant association is empirically shown. Henceforth, our study reinforces the study of Hesse and Poghosyan (2016) who document that bank performance is affected by the indirect impact of oil price shocks. In other words, the influence is first transmitted from oil price to macroeconomic factors and then to banking industries. Ultimately, Hesse and Poghosyan (2016) report that investment banks are more vulnerable to oil price shocks because of their buoyant advising fees and trading. In reality, some large commercial banks, such as Citigroup, are exposed to



oil-related asset trading. Henceforth, we gesture the likelihood that trading activities in big banks could enlarge their exposure to oil price shocks. Overall, our study suggests some

implications for both investors and policymakers. We suggest that the investor may consider variation of the interest rates in modeling their investment strategies. Moreover, policy makers

TABLE 5 | Variance decomposition analysis.

Period	WTI	Brent	Dubai	CPI	Industrial production	Interest rate
Panel A: Variance decomposition of US bank index						
1	0	0	0	0	0	0
3	6.539	0.204	0.063	0.054	0.072	0.074
6	20.268	0.302	0.72	2.933	0.743	5.703
9	32.703	1.163	0.968	4.691	5.516	19.463
12	29.892	1.275	2.059	3.232	11.331	31.521
15	22.803	0.951	3.301	1.755	13.514	42.623
18	18.148	0.814	3.88	0.954	12.11	51.394
20	16.238	0.793	4.04	0.639	10.64	55.854
Panel B: Variance decomposition of United Kingdom Bank Index						
1	0	0	0	0	0	0
3	3.117	0.094	0.033	0.109	0.202	0.095
6	3.294	1.432	0.526	2.784	1.09	0.157
9	7.129	4.221	1.367	7.066	2.228	1.891
12	13.033	7.094	2.032	8.393	3.044	4.611
15	15.495	9.574	2.771	8.499	3.499	6.315
18	15.892	11.459	3.472	8.77	3.713	7.369
20	15.911	12.402	3.824	9.219	3.785	8.007
Panel C: Variance decomposition of Canada Bank Index						
1	0	0	0	0	0	0
3	9.058	0.221	0.054	0.026	0.004	0.228
6	13.212	0.238	0.608	0.314	0.043	2.032
9	11.788	0.568	1.033	0.287	0.071	6.564
12	10.097	0.986	1.445	0.609	0.572	11.207
15	9.005	1.397	1.954	0.544	1.913	14.323
18	8.16	1.623	2.408	0.496	4.979	16.89
20	7.722	1.631	2.577	0.477	5.952	17.396
Panel D: Variance decomposition of Japan Bank Index						
1	0	0	0	0	0	0
3	4.016	0.545	0.895	0.56	1.566	5.502
6	2.553	0.806	2.442	2.318	3.118	13.226
9	3.893	0.586	2.581	23.884	4.528	14.391
12	5.366	0.782	2.024	5.737	5.747	13.006
15	5.188	1.29	1.648	7.001	7.188	11.668
18	4.411	1.613	1.39	7.414	9.131	10.964
20	4.153	1.629	1.312	7.363	10.702	10.831
Panel E: Variance decomposition of Mexico Bank Index						
1	0	0	0	0	0	0
3	12.821	0.081	0.841	0.175	0.118	0.093
6	24.131	0.533	3.23	0.137	0.167	1.165
9	28.78	0.979	2.981	0.417	0.368	0.964
12	31.177	0.991	2.544	1.184	0.588	0.781
15	34.162	0.97	2.384	1.751	0.917	0.675
18	37.883	1754	2.328	1.484	3.856	1.036
20	37.216	2.613	2.61	1.387	6.811	1.815
Panel F: Variance decomposition of Malaysia Bank Index						
1	0	0	0	0	0	0
3	0.153	0.225	0.16	0.05	0.232	0.068
6	0.101	1.457	3.113	0.186	0.184	0.783
9	0.124	1.101	5.558	0.967	0.258	7.791
12	0.105	0.819	9.037	1.576	0.187	10.092
15	0.231	0.845	11.061	1.299	0.276	16.031
18	0.676	1.056	11.986	2.006	0.504	22.702
20	1.132	1.374	11.78	4.183	0.548	25.974

(Continued on following page)

TABLE 5 | (Continued) Variance decomposition analysis.

Period	WTI	Brent	Dubai	CPI	Industrial production	Interest rate
Panel G: Variance decomposition of Brazil Bank Index						
1	0	0	0	0	0	0
3	8.335	0.02	0.118	0.401	0.658	2.932
6	16.328	0.283	1.189	0.279	1.351	4.543
9	19.249	0.288	1.096	2.582	1.156	10.005
12	17.837	0.862	0.937	11.009	0.91	14.848
15	14.616	1.188	0.709	20.704	0.85	18.601
18	11.919	1.071	0.534	28.825	0.831	20.961
20	10.586	0.898	0.442	33.146	0.811	22.15

may consider the estimation of the impact of interest rate adjustments on the bank performance. Finally, we suggest further exploration and insights on how oil price shocks impact the banking industry in emerging markets under different techniques, data, and contexts.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

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AUTHOR CONTRIBUTIONS

MS and DL are the main authors of this project. AH helped in the analysis.

SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at <https://www.frontiersin.org/articles/10.3389/fenrg.2021.595060/full#supplementary-material>

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