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Energy shocks and bank performance in the advanced economies

Asma Nasim [*], Gareth Downing

University of Huddersfield, United Kingdom

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ABSTRACT

This paper investigates the effects of energy price shocks on the performance of 62 major banks in the G7 advanced economies from 2001 to 2020. Employing numerous empirical techniques, including fixed effects, random effects, panel fully modified least squares, panel dynamic least squares, and GMM, the findings show that energy price shocks have a significant negative impact on banking sector performance, in terms of both return on assets and return on equity. This result holds true even after controlling for a range of key macro and financial variables, suggesting energy price shocks can have a direct impact on banking performance. Given the importance of banks for both financial stability and wider economic performance, and given the recent surge in energy prices, these findings have important implications for policymakers, regulators, as well as banking sector stakeholders.

1. Introduction

Energy plays a key role in the global economy, its use being key to production, transport and numerous other economic activities. Energy demand is therefore highly inelastic and, when energy prices change, it has important implications for households, companies and governments. Unfortunately, energy prices have also proven to be highly volatile in recent decades (see Fig. 1 below). These fluctuations are widely viewed as an important driver of economic instability, as has once again been clear following the recent energy crisis following the Russia-Ukraine war.

In much of the existing literature, it is common to use energy prices and oil prices interchangeably, with most of the empirical analysis focusing on the latter. This is because oil prices and energy prices tend to move together, and because oil is the most widely traded and strategically important global commodity. However, it is important to recognise that oil prices and energy prices are not quite the same. For instance, as Kilian (2008) points out, producers in the United States rely more on electricity and natural gas. As such, this study employs a global energy price index that provides a more comprehensive measure of energy prices than a simple focus on oil prices.

There is a large literature investigating the impact of energy price fluctuations on economic activity (e.g., Hamilton, 1983, 2009). A significant literature has also developed focusing on the effects of energy price volatility on financial markets (e.g., Sardosky Pedroni, 1999; Demirer et al., 2020). More recently, a growing literature has focused on the relationship between energy prices and the banking sector (e.g., Lee and Lee, 2019; Ma et al., 2021). However, this topic remains somewhat less understood. This paper adds to this literature by analysing the effect of energy price shocks on bank performance for advanced economies for the period 2001 to 2020.

Banks play a critical role in the capital allocation of an economy, they are substantial providers of funding for many economic sectors, and they are significant participants in the transmission of monetary policy from the central bank to the rest of the economy. The 2008 global financial crisis made it clear that disruptions to the banking sector have huge implications for the economy and society. It is therefore important to understand the influence of energy price shocks on the banking sector. This study focuses on how energy price shocks impact two key measures of banking sector performance: ***return on assets*** and ***return on equity***.

The paper makes three contributions to the literature. Firstly, it is the first such analysis on this topic that covers the G7 major advanced economies. This is important because developments in the G7 countries have a significant influence on the global economy and because the banking sectors of these economies are especially important for global financial stability. Secondly, it considers a wider energy price index rather than focusing more narrowly on oil prices. This is important because, although they often move together, oil prices and energy prices are not the same. And given much of the previous literature focuses more narrowly on oil prices, it is useful to know that results also hold for this more comprehensive measure of energy prices. Thirdly, the analysis accounts for the wider macroeconomic environment by including

* Corresponding author.
E-mail addresses: asma.nasim@hud.ac.uk (A. Nasim), g.m.downing@hud.ac.uk (G. Downing).

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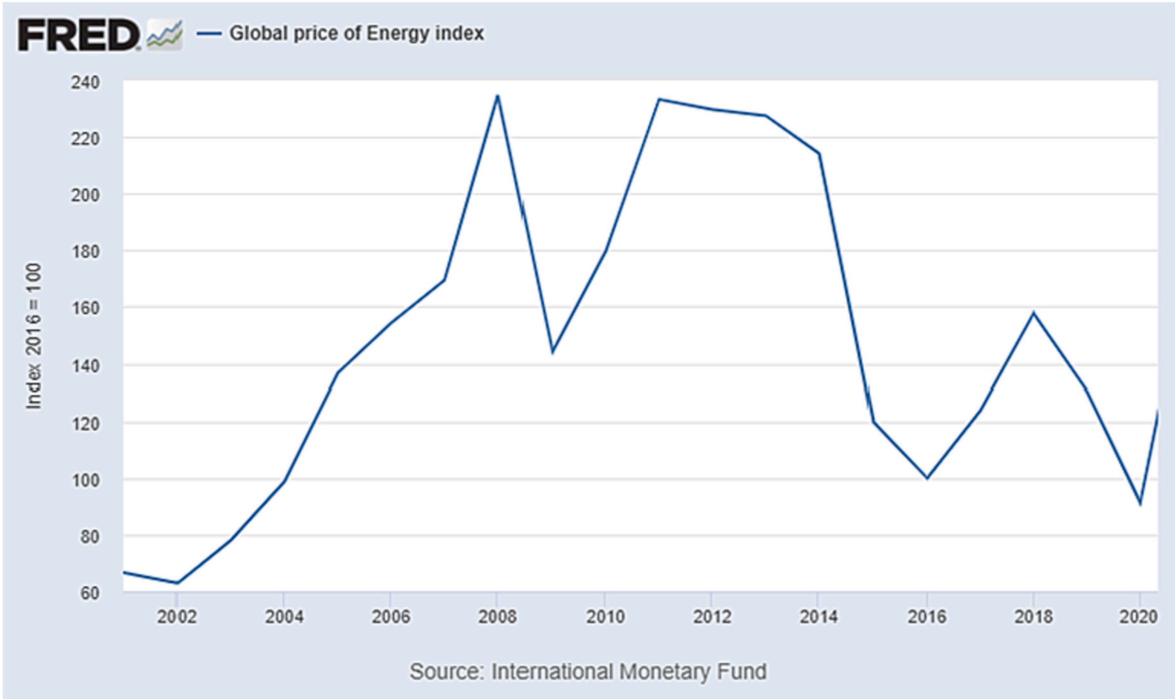

Fig. 1. Global energy prices.

factors such as economic growth, unemployment, inflation, policy uncertainty, monetary policy, exchange rate, capital adequacy and bank leverage. This is important because energy prices can potentially affect the banking sector both directly (by impacting bank assets) and indirectly (via the macroeconomy). Hence, in order to understand whether energy prices have a direct impact on bank performance, it is necessary to control for these key macroeconomic factors. Finally, it employs various empirical techniques including fixed effects, random effects, panel fully modified least squares, panel dynamic least squares and Generalised Methods of Moments. This is necessary to minimise problems of endogeneity and other potential issues.

The results of our analysis suggest that energy prices have a significant negative impact on bank performance and that this result holds even after macroeconomic variables have been accounted for, suggesting that energy price shocks can potentially have a direct impact on bank performance. Furthermore, and as expected, economic growth is found to be positively significant, while inflation is found to be negatively significant. Finally, both bank capital and bank leverage are also found to have an impact on bank performance.

The rest of the paper is structured as follows: The associated literature is reviewed in section 2, the data collection and methodology is described in section 3, and the empirical results and discussion are presented in section 4 and section 5 concludes.

2. Literature review

2.1. Energy shocks and the macroeconomy

The relationship between energy prices and economic activity has been the subject of considerable research since the large oil price shocks of the 1970s. Many early studies found a negative impact of rising oil prices on economic growth, at least within the major advanced economies (e.g., Bruno and Sachs, 1981, 1985; Darby, 1982; Hamilton, 1983; Burbidge et al., 1984; Gisser and Goodwin, 1986). Other studies have also found links between oil prices and other key macroeconomic variables, especially inflation (LeBlanc and Chinn, 2004; Choi et al., 2018). Building on this early literature, numerous studies have highlighted the complex nature of the relationship, with results depending on numerous factors, including: the time period analysed (Hamilton, 1996), whether the shocks are demand driven or supply driven (Kilian, 2009), whether the country analysed is oil-importing or oil-exporting (Killia et al., 2009), as well as structural differences between countries (Nasir et al., 2018a, 2019).[1]

There are numerous proposed mechanisms through which energy prices can effect economic activity. On the supply side, higher energy prices (i.e., input costs) reduce the profit maximising level of output (Hamilton, 1983). On the demand side, higher energy prices will be inflationary (Nasir et al., 2020, 2020b, 2020c; Pham et al., 2020) and can lead to lower real money balances (Solow, 1980), rising interest rates, lower real incomes and reduced consumption spending (Bernanke et al., 1997). The relative importance of the different channels is subject to debate. S ome authors have casted doubt on whether the supply side mechanism can really explain the full impact of energy price shocks. For instance, Bohi (1991) finds that energy intensive industries do not suffer worse following oil price rises, whilst several studies have shown that the strength of this channel must be relatively small given the low costs share of oil in GDP (Kilian, 2008). However, as Brown and Yucel (2002) point out, only the supply side explanation can readily explain how rising oil prices can lead to both a fall in GDP *and* rise in inflation.

Importantly, the relationship between oil prices and economic activity appears to be asymmetric, with rising oil prices reducing activity whilst falling oil prices failing to boost activity (Mor et al., 1994; Kilian and Vigfusson, 2011). Furthermore, the strength of the relationship seems to have weakened since the 1980s (Blanchard and Galí, 2007). This is partly because sectoral changes and technical advancements mean the major advanced economies are now less dependent on oil imports than they were in the 1970s. Going further, Segal (2011) challenges the view that oil price shocks themselves ever had a decisive impact on the macroeconomy, arguing instead they operate mainly through monetary policy. This can explain why rising oil prices up to 2008 had little negative impact on the global economy: because of

[1] For an excellent discussion of these issues see, for example, Kilian (2008).

increased central bank credibility and/or wage flexibility, rising oil prices did not feed through into core inflation and thus did not provoke a response from central banks. However, the recent energy crisis has once again reminded us that the relationship is complex, and that in some circumstances at least, energy price shocks can, and do, have serious effects on the economy.

2.2. Energy shocks and the financial system

The advance of globalisation in recent decades has increased links between energy markets and the financial system, with the result that large energy price fluctuations now have the potential to significantly impact financial markets. These effects can operate through numerous channels, including their effects on production costs and future cash flows, as well as via inflationary pressures and interest rates. Particularly in emerging markets and/or oil-exporting countries, oil prices may also impact government finances and exchange rates (Demirer et al., 2020). This has led to the development of a large literature focusing on the link between energy prices and financial markets. Once again, much of the focus is on oil prices, especially the relationship with stock markets (e.g., Sardosky Pedroni, 1999; Kilian and Park, 2009; Narayan and Gupta, 2015; Du and He, 2015; Nasir et al., 2018b), with a more limited focus on other financial markets including bond markets (e.g., Kang and Ratti, 2013; Narayan and Gupta, 2015; Demirer et al., 2020), exchange rates (e.g., Benassy-Quere et al., 2007; Chen and Chen, 2007; Narayan et al., 2008; Basher et al., 2016), cryptocurrencies (Huynh et al., 2021) and financial stability (e.g., Li et al., 2016; Qin, 2020).

2.3. Energy shocks and Bank performance

The focus of this paper is on the relationship between energy shocks and bank performance. Energy price shocks can potentially impact banks both directly, by affecting the value of bank assets (e.g., loans to energy companies), and indirectly, via macroeconomic factors that affect the banking sector. For instance, higher energy prices increase inflationary pressures which can increase credit market frictions that negatively impact banks (Huybens and Smith, 1999; Boyd et al., 2001). Moreover, higher energy prices may reduce economic growth and increase unemployment which can increase non-performing loans (NPLs), reduce lending (Hesse and Poghosyan, 2016), reduce margins (Bikker and Hu, 2002), and increase credit default risk (Makri et al., 2014; Idris and Nayan, 2016).

There is relatively little research directly analysing the link between energy prices and bank performance. One paper with a similar focus to ours is Lee and Lee (2019), who analyse the impact of oil prices on bank performance in China for the period 2000–2014. Using the CAMEL (capital adequacy, asset quality, management, earnings, and liquidity) indicators, they find that oil prices have a significant impact on banking performance. Similarly, Ma et al. (2021) investigate the relationship between oil prices and the stock returns of 16 major banks in China. They find that this relationship depends on whether the price shocks are demand or supply driven, and on whether the shocks are global or oil-specific in nature.

Several other papers have looked at the effect of oil prices on banks in oil-exporting countries of the Gulf Cooperation Council (GCC). Both Alodaynic (2016) and Ibrahim (2019) find that oil prices have a significant impact on bank NPLs, which then impact the macroeconomy. Using a behavioural finance perspective, Alqahtani et al. (2020) find a non-linear relationship between oil prices and banks, depending on the price of oil, while Saif-Alyousfi (2020) find that oil price shocks impact bank performance even when macro factors have been accounted for. Maghyereh and Abdoh (2021) find that oil-supply shocks have a bigger impact on bank risk than oil-demand shocks, and that this relationship has changed over time. Extending the analysis to a panel of 30 oil-exporting countries, Al-Khazali and Mirzaei (2017) find that an increase in oil prices reduces bank's NPLs. While these studies provide some important insights into the relationship between energy prices and bank performance, they do not cover the G7 advanced economies. Hence further research on this topic is required.

In the context of recent geopolitical events, notably the Russia-Ukraine war and resulting surge in energy prices, there are likely to be crucial challenges to the financial sector going forward (see, Qureshi et al., 2022; Gaio et al., 2022). Hence, it is vital to analyse the implications of energy shocks for the financial sector in general and banking sector in particular.

3. Data and methodology

3.1. Data

The data used in this investigation covers the period from 2001 to 2020. It is particularly interesting to consider this time period because it is marked by numerous important political and economic events, including the 2008 Global Financial Crisis, the Arab Spring, and the outbreak of Covid −19, as well as some considerable swings in energy prices. Data was collected on the G7 countries (Canada, France, Germany, Italy, Japan, the United Kingdom, the United States and the European Union) due to the significance of these economies for the global economy and because the banking sector of these economies are especially important for global financial stability. Data on energy prices was obtained from the World Bank. The study uses average annual global energy prices in US dollars.

Data on bank performance was obtained from Bank Scope. Annual reports of 62 major banks were used to compile data on the financial performance of the banking industry. Two key measures of bank performance are employed. Firstly, return on assets (ROA), which is calculated as net income over total assets. ROA is one of the key indicators of company performance, since it measures how well a company generates profits from its assets. Secondly, return on equity (ROE), which is calculated as net income divided by total equity. ROE is another key measure of company performance. It measures how effectively shareholder capital is being used to produce profit. Banks commonly set ROE goals and these goals are often a key component of CEO compensation. Two other control variables assessing the health of banks were also included: the capital adequacy ratio (CAP) which is the amount of capital banks must hold as a percentage of its risk-weighted assets (determined by regulators), and bank leverage as measured by debt-to-equity ratio. The macroeconomic data were gathered from the World Bank, the International Monetary Fund, and the central banks of the countries under study. The macroeconomic variables included are GDP growth rate, inflation (consumer price index), unemployment rate, bank rate, and the exchange rate (annual average exchange rate). The economic policy uncertainty index was also employed as a control variable.

3.2. Methodology

The econometric model employed in the analysis takes the following form:

$$bankperf_t = \beta_o + \beta_1 energyprice_t + \beta_2 GDP_t + \beta_3 inf_t + \beta_4 uneply_t + \beta_5 uncer_t$$
$$+ \beta_6 exch_t + \beta_7 bankrate_t + \beta_8 cap_t + \beta_9 lev_t + \varepsilon_t \tag{1}$$

Where:

- $bankperf_t$ is the measure of bank performance (either ROA or ROE)
- $energyprice_t$ is the global energy price index
- GDP_t is the economic growth rate
- inf_t is the inflation rate
- $uneply_t$is the unemployment rate
- $uncer_t$ is the economic policy uncertainty index
- $exch_t$ is the exchange rate
- $bankrate_t$ is bank rate

Table 1
Breitung, Hadri & Phillips-Perron (PP) unit root tests.

Variable	Test	Individual Intercept		Individual Intercept and Trend		Conclusion
		Level	1st Difference	Level	1st Difference	
Energy	Breitung			(2.36373) 0.991	(−21.1825.) 0.000***	Stationary after 1st difference
	PP	(130.492) 0.032	(605.834) 0.000***	(11.566) 1.000	(1244.24) 0.000***	Stationary after 1st difference
	Hadri	(2.78105) 0.002	(7.665) 0.000***	(21.782) 0.000***	(64.215) 0.000***	Stationary after 1st difference
GDP	Breitung			(9.8268) 1.000	(−6.7214) 0.000***	Stationary at level.
	PP	(450.688) 0.000***	(5012.30) 0.000***	(313.00) 0.000***	(772.11) 0.000***	Stationary at level.
	Hadri	(−1.4031) 0.919	(2.2933) 0.010*	(3.7129) 0.000***	(6.5910) 0.000***	Stationary after 1st difference.
Inflation	Breitung			(−15.8802) 0.000***	(−19.777) 0.000***	Stationary at level.
	PP	(444.893) 0.000***	(3263.70) 0.000***	(489.040) 0.000***	(1355.05) 0.000***	Stationary at level
	Hadri	(12.0539) 0.000***	(16.385) 0.000***	(7.6158) 0.000***	(77.3165) 0.000***	Stationary at level
Unemployment	Breitung			(6.5510) 1.000	−2.2250 0.001*	Stationary at 1st difference
	PP	(92.184) 0.985	(219.332) 0.000***	(55.679) 1.000	(586.156) 0.000***	Stationary after 2nd difference
	Hadri	(−2.5863) 0.995	(4.2817) 0.000***	(9.5894) 0.000***	(6.3471) 0.000***	Stationary after 1st difference
Uncertainty	Breitung			(11.3941) 1.000	(−2.7942) 0.002*	Stationary after 1st difference
	PP	(74.004) 0.999	(561.328) 0.000***	(78.068) 0.999	(427.611) 0.000***	Stationary after 1st difference
	Hadri	(18.175) 0.000***	(6.5644) 0.000***	(4.1644) 0.000***	(16.1589) 0.000***	Stationary at level
Exchange Rate	Breitung			(80861) 0.000***	(21.3246) 0.000***	Stationary at level
	PP	(285.388) 0.000***	(1496.34) 0.000***	(269.579) 0.000***	(1009.52) 0.000***	Stationary at level
	Hadri	(4.7659) 0.000***	(3.8863) 0.000***	(11.2902) 0.000***	(34.7422) 0.000***	Stationary at level
Bank Rate	Breitung			(−8.72108) 0.000***	(−4.26301) 0.000***	Stationary at level
	PP	(190.165) 0.000***	(649.743) 0.000***	(150.880) 0.050	(500.186) 0.000***	Stationary at level
	Hadri	(16.088) 0.000***	(4.5455) 0.000***	(3.3941) 0.000***	(6.0042) 0.000***	Stationary at level
Capital adequacy	Breitung			(1.2265) 0.890	−10.929) 0.000***	Stationary at 1st difference
	PP	(435.273) 0.000***	(1991.17) 0.000***	(215.911) 0.000***	(883.44) 0.000***	Stationary at level
	Hadri	(8.6589) 0.000***	(8.3168) 0.000***	(11.941) 0.000***	(11.8814) 0.000***	Stationary at level
ROA	Breitung			(−4.5686) 0.000***	(−10.8735) 0.000***	Stationary at level
	PP	(444.761) 0.000***	(3213.54) 0.000***	(367.552) 0.000***	(969.736) 0.000***	Stationary at level
	Hadri	(−1.3680) 0.914	(12.635) 0.000***	(3.5089) 0.000***	(64.021) 0.000***	Stationary at level
ROE	Breitung			(−5.9153) 0.000***	(−12.556) 0.000***	Stationary at level
	PP	(463.01) 0.000***	(3088.26) 0.000***	(364.180) 0.000***	(946.840) 0.000***	Stationary at level
	Hadri	(−1.3490) 0.911	(12.924) 0.000***	(2.7675) 0.002*	(63.714) 0.000***	Stationary at 1st difference
Leverage	Breitung			(0.10239) 0.540	(−11.9263) 0.000***	Stationary at 1st difference
	PP	(192.949) 0.000***	(948.641) 0.000***	(138.705) 0.173	(781.535) 0.000***	Stationary at 1st difference
	Hadri	(5.9618) 0.000***	(17.362) 0.000***	(9.2226) 0.000***	(80.7328) 0.000***	Stationary at level

Statistic is in brackets; *, ** and *** = 10%, 5% and 1% significance levels respectively.

Table 2
Kao cointegration test for the for both dependent variables.

ROA	−22.99624	0.000***
ROE	−15.04263	0.000***

Statistic is in brackets; *** = 1% significance level.

Table 3
Pedroni co-integration test for ROA.

VARIABLES	Test statistics	I·I	I·I and I. T	No, I or T
ROA GDP inflation unemployment Bank rate leverage, Energy	Panel v Statist	−0.334407 (0.631)	−3.393009 (0.999)	0.726876 (0.233)
	Panel rho Statistic	1.1588617 (0.943)	4.247023 (1.000)	−0.260555 (0.397)
	Panel PP Statistic	−38.16109 0.000***	−51.28264 0.000***	−29.45383 0.000***
	Panel ADF Statistic	−26.80124 0.000***	−28.98773 0.000***	−23.96110 0.000***
ROA GDP inflation unemployment capital, leverage Energy	Panel v Statist	−0.810246 (0.791)	−3.725337 0.999	0.138136 0.445
	Panel rho Statistic	1.358960 0.912	4.329220 1.000	−0.32541 0.372
	Panel PP Statistic	−36.36829 0.000***	−45.95529 0.000***	−29.08164 0.000***
	Panel ADF Statistic	−27.34647 0.000***	−28.41447 0.000***	−24.12138 0.000***
ROA GDP inflation unemployment capital, exchange rate, Energy	Panel v Statist	7.508304 0.000***	4.285077 0.000***	8.799851 0.000***
	Panel rho Statistic	0.745489 (0.772)	5.007435 1.000	−1.022032 0.153
	Panel PP Statistic	−18.00712 0.000***	−27.02090 0.000***	−17.70731 0.000***
	Panel ADF Statistic	−17.82177 0.000***	−20.49029 0.000***	−17.61337 0.000***
ROA GDP inflation unemployment capital, uncertainty, Energy	Panel v Statist	−3.11974 (0.999)	−6.795074 1.000	−1.77710 (0.962)
	Panel rho Statistic	3.167518 (0.999)	5.779336 (1.000)	0.123315 (0.549)
	Panel PP Statistic	−15.13850 0.000***	−13.38314 0.000***	−14.80242 (0.000***
	Panel ADF Statistic	−14.22809 0.000***	−12.43472 0.000***	−14.63214 0.000***

Statistic is in brackets; w = Weighted Statistic; *** = 1% significance level; I·I. = Individual Intercept; I·I. and I.T. = Individual Intercept and Individual Trend; No, I or T = No Intercept or Trend.

- cap_t is bank capital
- lev_t is bank leverage

And where, β_1, β_2, β_3, β_4, β_5, β_6, β_7, β_8 and β_9 are the coefficients of explanatory variables while ε is a stochastic error term which is i.i.d.

It is widely accepted that global energy prices (especially oil prices) have been endogenous with respect the US economy, at least going back to the early 1970s (Kilian, 2008). This is because of reverse causality: not only do energy prices affect the US economy, but developments in the US economy can affect energy prices. The endogeneity issue is even more pronounced when analysing global or regional effects (e.g., G7). As such, we employ numerous estimation techniques that reduce endogeneity problems as well as other potential issues. We employed a set of novel empirical approaches for robustness and to overcome limitations associated with a single approach. The estimators employed are fixed effects (FE) and random effects (RE), dynamic fully modified ordinary least squares (FMOLS), panel dynamic least squares (DOLS), and finally the generalised method of moments (GMM). While the FE and RE estimators effectively address variable heterogeneity, they are static estimators unable to handle endogeneity problems, making alternative methods appealing. The DOLS takes into consideration the leads and lags of the explanatory variables in the initial variations, while the FMOLS estimator uses the Newey-West technique to account for serial correlation and endogeneity biases. As a result, they function better in small datasets in reducing problems of serial correlation and endogeneity. The GMM estimator employs all lagged values of the dependent variable that are currently available as well as lagged values of the exogenous regressors as potential endogeneity-receptive instruments. The GMM estimator additionally considers the persistent nature of the dependent variable as well as unobserved heterogeneity. Generally, the estimations of the parameters produced by this method are reliable than other estimators (see, Ullah et al., 2018, 2021).

Table 4
Test of Pedroni-cointegration for ROE.

Variables	Test statistics	I.I	I.I and I. T	No, I or T
ROE, GDP,Inflation, capital, unemployment, Energy, Bankrate	Panel v Statist	−8.693591 1.000	−12.05404 1.000	−6.826760 1.000
	Panel rho Statistic	3.732900 0.999	6.489380 1.000	1.817082 0.965
	Panel PP Statistic	−92.51364 0.000***	−78.58382 0.000***	−74.64572 0.000***
	Panel ADF Statistic	−23.56138 0.000***	−21.15445 0.000***	−20.14820 0.000***
ROE, GDP, Inflation, capital, unemployment, Energy, uncertainty	Panel v Statist	−10.05263 (1.000)	−13.33096 (1.000)	−8.29091 (1.000)
	Panel rho Statistic	4.26360 (1.000)	6.843101 (1.000)	0.83886 (0.799)
	Panel PP Statistic	−66.8986 0.000***	−81.15492 0.000***	−38.5226 (0.000***
	Panel ADF Statistic	−15.6469 0.000***	−15.55196 0.000***	−24.9989 0.000***
ROE, GDP, Inflation, leverage, unemployment, Energy, uncertainty	Panel v Statist	(0.47305) 1.000	(−2.0565) 1.000	(1.82825) 1.000
	Panel rho Statistic	2.5712 (1.000)	(7.8731) 1.000	(1.70128) 0.955
	Panel PP Statistic	(−61.9823) 0.000***	(−77.8165) 0.000***	(−63.25786) 0.000***
	Panel ADF Statistic	(−12.3713) 0.000***	(−9.97894) 0.000***	(13.9042) 0.000***
ROE, GDP, Inflation, Exchange rate, unemployment, Energy, uncertainty	Panel v Statist	(−9.12041) 1.000	(−12.4742) 1.000	(−7.20408) 1.000
	Panel rho Statistic	(5.60846) 1.000	(8.27536) 1.000	(3.89355) 1.000
	Panel PP Statistic	(−44.5965) 0.000***	(−50.4291) 0.000***	(−40.8477) 0.000***
	Panel ADF Statistic	(−18.16047) 0.000***	(−17.1624) 0.000***	(−18.9129) 0.000***

Statistic is in brackets; w = Weighted Statistic; *** = 1% significance level; I.I. = Individual Intercept; I.I. and I.T. = Individual Intercept and Individual Trend; No I or T = No Intercept or Trend.

4. Analysis and results

4.1. Panel unit root tests

As a preliminary step, three alternative unit root test were employed on all variables, those by Breitung (2000), Hadri (2000) and Phillips and Perron (1988).[2] Breitung (2000) generated a panel unit root test that does not require bias correlation factors, which is accomplished by appropriate variable transformation. The test statistics are t-ratios with good power qualities in the neighbourhood of unity. The Hadri (2000) z-stat panel unit root test acknowledges the existence of stationarity processes that are identical across cross-sections. The Phillips and Perron (1988) test corrects the *t*-test statistic in a non-parametric manner, making it resistant to non-specific autocorrelation and endogeneity. The results of the tests are shown in Table 1 below. As the table shows, the variables employed are all stationary either at level or first difference.

4.2. Panel cointegration tests

Next, two alternative tests for cointegration between bank performance and the independent variables were employed, those by Kao (1999) and Pedroni (1999). The results of the Kao (1999) residual cointegration test are reported in Table 2 below. The results suggest there is no long-term relationship between either ROA or ROE and the independent variables.

The results of Pedroni (1999) test on ROA are reported in Table 3 below. The results reveal no co-integration between ROA and the independent variables because the *p*-values for the relevant statistics are all insignificant at the 1% level.

The results of Pedroni (1999) test on ROE are reported in Table 4 below. The results indicate there is cointegration between ROE and the independent variables in model I and II, suggesting the possibility of a long run relationship.

Table 5
Energy shocks & banking sector performance I: ROA.

Variables	FE	RE	FMOLS	DOLS
Energy price	(4.33E-06) 0.840	(2.97E-06) 0.886	(1.8E-05) 0.393	(−1.98E-05) 0.423
GDP	(0.000532) 0.736	(0.001572) 0.253	(0.002045) 0.173	(0.014727) 0.035
Inflation	(0.000459) 0.855	(−0.000610) 0.777	(−0.000391) 0.871	(−0.564033) 0.000***
Unemployment	(−0.00011) 0.938	(0.000827) 0.235	(0.000624) 0.395	(−0.33842) 0.009***
Uncertainty	(−2.24E-05) 0.267	(−1.02E-06) 0.947	(6.16E-06) 0.713	(7.64E-06) 0.566
Capital adequacy	(−0.00015) 0.967	(−0.637E-05) 0.985	(0.022124) 0.520	(−0.03702) 0.463
Exchange rate	(−3.21E-05) 0.703	(−6.99E-05) 0.349	(−4.35E-05) 0.429	(0.00017) 0.257
Bank rate	(0.141289) 0.174	(0.263672) 0.001 ***	(0.316782) 0.000 ***	(0.050716) (0.693)
Leverage	−6.34E-06	−1.71E-05 (0.664)	−3.10E-05 (0.463)	0–0.001859 (0.406)
R-square	0.087891	0.016261	0.0186	−170.712
F STATISTIC	1.596831	2.2425		
Prob	0.001***	0.017**		
D W TEST	2.1342	2.023		
H Test	(16,697.76) 0.000***	(15,226.0) 0.000***	(7262.67) 0.000***	(15,226.0) 0.000***

Coefficients are in brackets; *, ** and *** = 10%, 5% and 1% significance levels respectively; D—W statistic = Durbin Watson statistic; A. test statistic = Autocorrelation test statistic where Chi-square Distribution at 5% significance level is 16.07; H. test statistic = Heteroscedasticity test statistic where Chi-square Distribution at 5% significance.

Table 6
Energy shocks & banking sector performance (*ROE*).

Variables	FE	RE	FMOLS	DOLS
Energy price	(0.000306) 0.352	(0.000187) 0.558	(0.000358) 0.292	(0.000929) 0.008***
GDP	(0.00953) 0.870	(0.014150) 0.502	(0.003343) 0.890	(0.346030) 0.012
Inflation	(0.003934) 0.918	(0.022497) 0.495	(0.036779) 0.341	(−1.838177) (0.030**
Unemployment	(−0.021377) 0.363	(0.003308) 0.755	(−0.017195) 0.469	(−1.708569) 0.027**
Uncertainty	(0.000151) 0.625	(0.000104) 0.661	(0.000137) 0.657	(0.000379) 0.584
Capital adequacy	(0.002431) 0.945	(−0.000834) 0.988	(0.224304) 0.739	(−0.658563) 0.332
Exchange rate	(0.000719) 0.578	(0.000339) 0.766	(0.000253) 0.847	(0.00327) 0.000***
Bank rate	4.568784 0.004***	4.471209 0.000***	4.164868 0.016*	(6.052458) 0.032*
Leverage	(−9.41E-05) 0.878	(−0.000179) 0.766	(−0.000113) 0.851	(0.017285) (0.737
R-square	0.0796	0.02022	0.082356	−165.513
F STATISTIC	1.436019	2.802229		
Prob	0.0124			
D W TEST	2.1871	2.0914		
H Test	16,948.45 0.000***	16,631.48 0.000***	16,090.47 0.0000***	9464.245 0.000***

Coefficients are in brackets; *, ** and *** = 10%, 5% and 1% significance levels respectively; D—W statistic = Durbin Watson statistic; A. test statistic = Autocorrelation test statistic where Chi-square Distribution at 5% significance level is 18.07; H. test statistic = Heteroscedasticity test statistic where Chi-square Distribution at 5% significance is =18.07.

4.3. Panel estimations for bank performance

Next, panel regressions were carried out to analyse the relationship between energy prices and bank performance. Table 5 below presents the results of the panel estimations on the relationship between energy prices and return on assets (ROA). The table includes the fixed effects (FE) and random effects models (RE), fully modified OLS (FMOLS) and dynamic OLS (DOLS) model. The result reveal an insignificant link between bank performance and energy prices under all specifications. Only bank rate, inflation and unemployment were found to be significant, and only in some specifications.

Table 6 below presents the results of the same set of panel estimations, but this time focusing on return on equity (ROE). The results of the DOLS estimator suggest that energy price shocks are positively related to bank performance. This is a somewhat surprising result. Several other variables were also found to be significant under this specification, namely the inflation rate (negatively), the unemployment rate (negatively), the exchange rate (positively) and bank rate (positively) - the latter being significant under all estimators. These results are in line with existing theory and empirical analysis.

Finally, the System Generalised-Method-of-Moments (GMM) estimator developed by Blundell and Bond and Arellano in 1995 is employed to assess the relationship between bank performance and energy price shocks. The results are shown in Table 7 below. In line with previous research (Lee and Lee, 2019; Ma et al., 2021), the results suggest that energy prices have a significant negative impact on bank performance. Note this result holds even after macroeconomic variables have been accounted for, suggesting that energy price shocks can potentially have a direct impact on bank performance. Many of the

[2] The results of descriptive statistics and correlation analysis are concealed to conserve the space but are available upon request from corresponding author.

Table 7
Energy shock & banking sector performance: system GMM analysis.

Variable	ROA	ROE
Energy price	(−2.71E-05) 0.000***	−7.27E-05 0.093*
GDP	(0.000499) 0.000***	(0.037125) 0.000***
Inflation	(−0.004346) 0.000***	(−0.079354) 0.000***
Unemployment	(0.001794) 0.000***	(0.020262) 0.000***
Uncertainty	−1.19E-05 0.000***	2.43E-05 0.381
Leverage	(−0.003798) 0.000***	(0.011948) 0.000***
Bankrate	(0.491920) 0.000***	(9.177330) 0.000***
Exchange rate	(−0.000195) 0.000***	(0.002452) 0.000***
Capital	(−0.257956) 0.000***	(2.219448) 0.000***
Hansen J-Stat.	56.53828	54.78207
Prob(J-Stat)	0.275	0.333
Instrument rank	61	61
AR (1)	(−1.355386) 0.175	(−1.015817) 0.309
AR (2)	0.606877 0.543	−0.716854 0.473
Observations	1107	1108

Note: The dependent variable is a TOPSIS aggregated performance indicator. Columns 1–3 evaluate the consequences of estimating each component of national risk separately. The two-step GMM dynamic panel estimator is used for estimate. The measurements are lag levels for disparities and lag levels for variations. The Sargan test is an overidentification test in which the null hypothesis is that instrument use is unrelated to residuals. The Arellano-Bond serial correlation test (AR(2)) assumes that a second-order serial correlation does not exist in the differenced error terms. ** p- value <0.05, *** < 0.01, and * < 0.10.

control variables are also found to be significant under the GMM approach. As expected, economic growth is found to be positively significant. This is because a faster growing economy and the associated favourable economic environment may experience fewer non-performing loans (NPLs), higher lending (Hesse and Poghosyan, 2016), higher profit margins (Bikker and Hu, 2002), and reduced credit risk (Makri et al., 2014; Idris and Nayan, 2016). Also, in line with expectations, inflation is found to be negatively significant. This is because higher inflationary pressures can increase credit market frictions that negatively impact banks (Huybens and Smith, 1999; Boyd et al., 2001). Bank capital and bank leverage are both found to have negative impact return on assets but positive on return on equity, in line with the findings of Hasanov et al. (2018) but contrasting with Le et al. (2020).

5. Conclusion & implications

While the association between energy price shocks and macroeconomic performance has received much attention, relatively little is known about the relationship between energy prices and the banking sector. This paper adds to this burgeoning literature by analysing the relationship between energy price shocks and bank performance in the G7 advanced economies for the period 2001 to 2020. Furthermore, it considers the wider energy price index rather than focusing more narrowly on oil prices. The investigation also accounts for the wider macroeconomic environment by including factors such as economic growth, unemployment, inflation, policy uncertainty, monetary policy, credit conditions, exchange rate, capital adequacy and bank leverage. These factors are important in the context of energy shocks and its implications for the banking sector. The analysis employs various empirical techniques including fixed effects, random effects, panel fully modified least squares, panel dynamic least squares and Generalised Methods of Moments. The results suggest that energy price shocks have a direct negative impact on bank performance in the advanced economies, even when macroeconomic factors have been accounted for.

Banks are highly susceptible to energy price shocks because of the close relationship between financial markets and the energy sector. One of the key channels through which energy price shocks impact bank performance is likely to be through energy-related lending. For example, it is estimated that the US bank Wells Fargo bank had $42 billion worth of exposure to the energy sector in 2016, while stress tests predicted major European banks such as HSBC and Standard Chartered could lose billions from energy price shocks (Shaiban et al., 2021). There may well be further channels through which energy price shocks can directly impact the banking sector. Further research is required to identify such mechanisms and assess their relative importance. Additionally, we found that energy prices influence economic growth, inflation, exchange rates, bank rates, bank leverage and bank capital, all of which potentially open up indirect channels for energy prices to impact the banking sector.

Based on these findings, there are various policy implications that can be drawn. Firstly, banks are advised to protect themselves by strengthening their ability to resist energy price shocks. Secondly, while monetary policy can potentially help countries to mitigate the impact of energy price shocks, a delicate balance must be struck. For instance, a tighter monetary policy in response to the current spike in energy prices could lead to an unnecessary economic downturn, whilst an insufficient response could lead to an excessive rise in inflation. More generally, as there are structural differences between economies, including how dependent they are on energy imports, it is clear that monetary policy makers in each country must respond differently to any given energy shock (Nasir et al., 2018a). However, it is unlikely that monetary policy alone can fully offset significant energy price shocks. As such, it is important for banks themselves to be resilient in the face of such events. As a venue for further research, the focus could be on the effects of energy price shocks on banking performance in emerging markets, and on assessing this relationship based on countries net energy export position or energy mix.

Appendix A. Appendix

Variable	Source	Definition
Energy Prices	https://fred.stlouisfed.org	The global price of energy index compiled by the International Monetary Fund.
Bank Performance	http//thomsonreuters.net	Two measures were employed. Return on assets (ROA) is used as a measure of the banks' earning effectiveness. It is determined by the ratio of banks' profits to total assets. Return on equity (ROE) reveals how effectively a bank can turn a profit from the capital that shareholders have invested. It is calculated as net income divided by total equity.
Economic Growth Rate	https://www.macrotrends.net/	The annual growth rate of real gross domestic product (GDP) is used to measure economic growth.

(continued on next page)

(*continued*)

Variable	Source	Definition
Inflation Rate	https://www.macrotrends.net/	Annual growth grate of the consumer price index is used as a measure of the inflation rate.
Unemployment Rate	https://www.macrotrends.net/	The percentage of the labour force that is unemployed is known as the unemployment rate.
Exchange Rate	https://www.macrotrends.net/	The exchange rate (EXR) used in this study is the twelve-month average exchange rate.
Uncertainty Index	https://www.bis.org/	This study utilized the economic policy uncertainty (EPU) index introduced by Basher et al. (2016).
Bank Rate	http//thomsonreuters.net	The central bank's policy rate or levy on loans and advances made to commercial banks.
Capital Adequacy Ratio	http//thomsonreuters.net	Bank's capital adequacy is measured in relation to its risk-weighted assets using the capital adequacy ratio.
Leverage Ratio	http//thomsonreuters.net	Leverage ratio indicates the financial health of banks. It is measured as the debt-to-equity ratio of bank

Appendix B. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.eneco.2023.106517.

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